

CORSAIR ONE A200
The best SFF work PC
you can buy **PG. 76**



OPTIMIZING VR
Boost the Oculus
Quest 2 to the max! **PG. 64**



RASPBERRY PI
Get your RPi running with
our ultimate guide **PG. 40**



MAXIMUM PC

MINIMUM BS • JULY 2021 • www.maximumpc.com

NEXT-GEN PROCESSING

Intel's past, present, &
future unwrapped

- ✓ Sneak peek at Team Blue's next CPUs
- ✓ Sunny Cove vs. Zen 3: The nanometer wars
- ✓ DDR5 and PCIe 5.0 standards analyzed

PLUS!

AMD & Nvidia
graphics card
smackdown
PG. 72

**BUILD
THIS
SUPER-
SLICK
GAMING
PC** **PG. 18**

PC GAMING HISTORY

From Pong to Portal, dive
into our pixel past **PG. 48**





STEP UP YOUR GAME



The latest games at their highest settings are no match for the cutting-edge **CORSAIR VENGEANCE i7200 Series Gaming PC**. Powered by a blisteringly fast 10th Gen Intel® Core™ processor and ultra-lifelike NVIDIA® GeForce RTX™ 30 Series graphics, complete with a full range of celebrated CORSAIR components, VENGEANCE PCs take gaming to new heights.



only allows those loyal to her.



VENGEANCE
THE GAMING PC FROM CORSAIR

Find out more at [CORSAIR.COM](https://www.corsair.com)

BLAZING PERFORMANCE

\$3,349

NP9670M NOTEBOOK FREE UPS GROUND SHIPPING*

- Windows 10 Home
- 10th Gen Intel® Core™ i9-10900K Processor
- 17.3" Thin Bezel Full HD, 144Hz, 72% NTSC Matte Display with G-SYNC
- Opt. 4K UHD Matte Display with G-SYNC
- NVIDIA® GeForce™ RTX 2080 Super 8GB GPU
- Opt. GeForce™ RTX 2070 Super or RTX 2060 GPU
- 32GB DDR4-3200MHz Memory
- 1TB NVMe M.2 SSD
- RGB Per Key Illuminated Keyboard with N-Key Rollover
- Intel® Dual Band Wireless Wi-Fi 6 AX201 + BT
- Sound Blaster ATLAS Audio with Super X-Fi Technology

\$1,599

NP8358F2 NOTEBOOK After \$150 Instant Savings!

- Windows 10 Home
- 10th Gen Intel® Core™ i7-10875H Processor
- 15.6" Thin Bezel Full HD, 144Hz 72% NTSC Matte Display
- Opt. 17.3" FHD 144Hz 72% NTSC, G-SYNC Display (NP8378F2)
- NVIDIA® GeForce™ RTX 2070 Super 8GB GPU
- 16GB DDR4-3200MHz Memory
- 500GB NVMe M.2 SSD
- Single Zone Multi-Color Backlight Keyboard
- Intel® Dual Band Wireless Wi-Fi 6 AX201 + BT

\$1,499

NP8752D2 NOTEBOOK FREE UPS GROUND SHIPPING*

- Windows 10 Home
- 10th Gen Intel® Core™ i7-10875H Processor
- 15.6" Thin Bezel Full HD 144Hz, 72% NTSC Matte Display
- NVIDIA® GeForce™ RTX 2060 6GB GPU
- Opt. GeForce™ RTX 2070 GPU (NP8752F1), RTX 2080 Super GPU (NP8752N2)
- 16GB DDR4-3200MHz Memory
- 500GB NVMe M.2 SSD
- Single Zone Multi-Color Backlight Keyboard
- Intel® Dual Band Wireless Wi-Fi 6 AX201 + BT



Windows 10



NP8770F1 NOTEBOOK
FREE UPS GROUND SHIPPING*

\$1,699

- Windows® 10 Home
- 10th Gen Intel® Core™ i7-10875H Processor
- 17.3" Thin Bezel Full HD 144Hz, 72% NTSC Matte Display
- NVIDIA® GeForce™ RTX 2070 8GB GPU
- Opt. RTX 2060 GPU (NP8770D2), RTX 2080 Super GPU (NP8770N2)
- 16GB DDR4-3200MHz Memory
- 500GB NVMe M.2 SSD
- Single Zone Multi-Color Backlight Keyboard
- Intel® Dual Band Wireless Wi-Fi 6 AX201 + BT



NP7877DW-S NOTEBOOK
After \$150 Instant Savings!

\$1,499

- Windows® 10 Home
- 10th Gen Intel® Core™ i7-10875H Processor
- 17.3" Thin Bezel Full HD 144Hz Matte Display
- NVIDIA® GeForce™ RTX 2060 6GB GPU
- 32GB Dual Channel DDR4-3200MHz Memory
- 1TB NVMe M.2 SSD
- Single Zone Multi-Color Backlight Keyboard
- Intel® Dual Band Wireless Wi-Fi 6 AX201 + BT



NP7858DW NOTEBOOK
After \$100 Instant Savings!

\$1,299

- Windows® 10 Home
- 10th Gen Intel® Core™ i7-10875H Processor
- 15.6" Thin Bezel Full HD 144Hz Matte Display
- NVIDIA® GeForce™ RTX 2060 6GB GPU
- 16GB DDR4-3200MHz Memory
- 500GB NVMe M.2 SSD
- Single Zone Multi-Color Backlight Keyboard
- Intel® Dual Band Wireless Wi-Fi 6 AX201 + BT



NP7958C NOTEBOOK
FREE UPS GROUND SHIPPING*

\$1,299

- Windows® 10 Home
- AMD Ryzen™ 7 3700X Processor
- Opt. AMD Ryzen™ 9 Processor
- 15.6" Thin Bezel Full HD 144Hz Matte Display
- NVIDIA® GeForce™ GTX 1660Ti 6GB GPU
- Opt. GeForce™ RTX 2070 GPU (NP7958F1)
- 16GB DDR4-3200MHz Memory
- 500GB NVMe M.2 SSD
- Single Zone Multi-Color Backlight Keyboard
- Intel® Dual Band Wireless Wi-Fi 6 AX200 + BT



NP6877CQ NOTEBOOK
FREE UPS GROUND SHIPPING*

\$1,249

- Windows® 10 Home
- 10th Gen Intel® Core™ i7-10750H Processor
- 17.3" Thin Bezel Full HD 144Hz Matte Display
- NVIDIA® GeForce™ GTX 1660Ti 6GB GPU
- Opt. GeForce™ GTX 1650 GPU (NP6877BQ), GTX 1650Ti GPU (NP6877EQ)
- 16GB DDR4-2933MHz Memory
- 500GB NVMe M.2 SSD
- Single Zone Multi-Color Backlight Keyboard
- Intel® Dual Band Wireless Wi-Fi 6 AX201 + BT



NP6858BQ NOTEBOOK
FREE UPS GROUND SHIPPING*

\$1,049

- Windows® 10 Home
- 10th Gen Intel® Core™ i7-10750H Processor
- 15.6" Thin Bezel Full HD 144Hz Matte Display
- NVIDIA® GeForce™ GTX 1650 4GB GPU
- Opt. GeForce™ GTX 1650Ti GPU (NP6858EQ), GTX 1660Ti GPU (NP6858CQ)
- 16GB DDR4-2933MHz Memory
- 500GB NVMe M.2 SSD
- Single Zone Multi-Color Backlight Keyboard
- Intel® Dual Band Wireless Wi-Fi 6 AX201 + BT

CALL US TOLL FREE: **1.800.669.1624** CUSTOMIZE & PRICING GO ONLINE: **SAGERNOTEBOOK.COM**

Dealer/Var. government and corporate pricing are available. Please call for details.

inside

JULY 2021

SUBSCRIBE
TODAY!
PG. 38

QUICKSTART

- 10 THE NEWS**
Bitcoin's bubble; hackers cut fuel supply; Windows 10X dead; more.
- 13 TECH TALK**
Goodbye mining, hello farming—chia changes the crypto market.
- 15 TRADE CHAT**
Tech is everywhere, so why are hospitals so behind?

Find out whether our
Xiaomi Mi Watch teardown
went like clockwork.



R&D

- 57 HOW TO**
Make a mock-up; have more fun with the Oculus Quest 2; mod your PC with 3D-printed parts; more.
- 58 AUTOPSY**
We take time out to see what makes the Xiaomi Mi Watch 2021 tick.

LETTERS

- 16 DOCTOR**
- 94 COMMENTS**

IN THE LAB

18
ROCKET
LAKE
GAMING
PC**30**
UNPACKING
ROCKET LAKE

After Intel's Rocket come the Alders, Raptors, and Meteors.

40
GETTING STARTED
WITH RASPBERRY PI

Follow our beginner's guide to getting a Raspberry Pi up and running.

48
PC GAMING:
A HISTORY

PC gaming has come a long way. We look at where it's been and where it might go next.

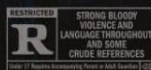


© SQUARE ENIX, EVIDA

GET OVER HERE



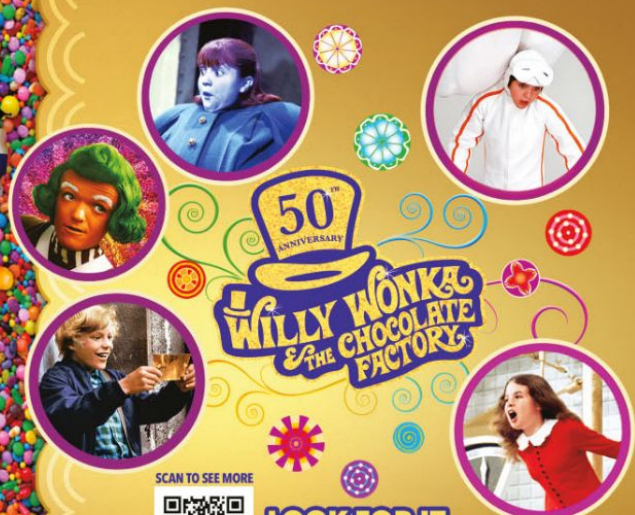
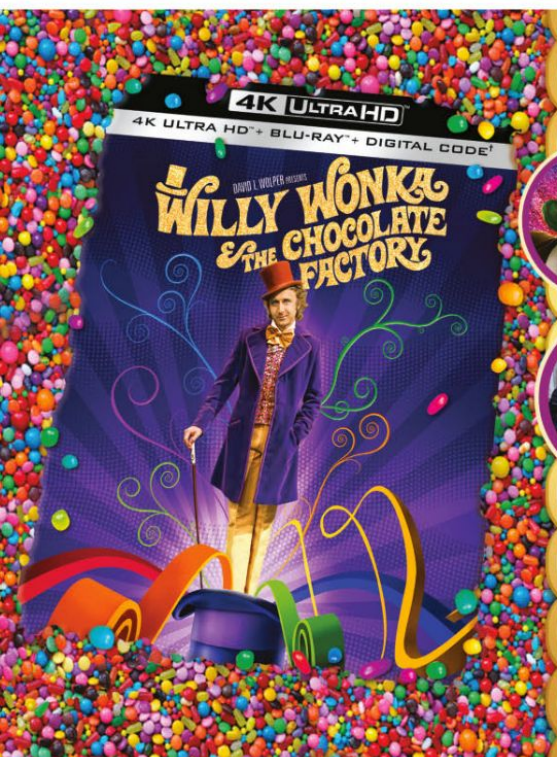
LOOK FOR IT ON DIGITAL AND 4K ULTRA HD™



NEW LINE CINEMA PRESENTS AN ATOMIC MONSTER/BROKEN ROAD PRODUCTION "MORTAL KOMBAT" LEWIS TAN, JESSICA MANABE, JOSH LAWSON
TADANOBU ASANO, MACHICO BROOKS, LUDU LIN, WITH CHIN HAN, JOE TASLIM, AS SHAN AND SON-PEI, AND HIROYUKI SANADA AS BANGS AND CAI SHIYU
WRITTEN BY DAN LEVENTAL, AND SCOTT GRAY, AND PRODUCED BY NARIMAN MARSHALL, AND JESSICA GERMAN, AND MACKENZIE AGS, AND RICHARD GREENER, DAVE NEUBARTER, VICTORIA PALMER, MICHAEL CLARK, JEREMY STEIN, LAWRENCE KASANOFF
DIRECTED BY ANDREW ED BOOM, AND JOHN TUBIAS, AND WRITTEN BY OREN UZIEL, AND GREG RUSSO, AND PRODUCED BY GREG RUSSO, AND DAVE CALLAHAN, AND WRITTEN BY JAMES WAN, TODD GARNER, AND SIMON MACDOUGALL, E. BENNETT WALSH, AND PRODUCED BY SIMON MACDOUGALL
facebook.com/MortalKombatMovie #MortalKombatMovie

STRONG BLOODY VIOLENCE AND LANGUAGE THROUGHOUT, AND SOME CRUDE REFERENCES

NEW LINE CINEMA 4K ULTRA HD Blu-ray DVD 50th Anniversary Warner Bros. Entertainment Inc. Special Features are not MPAA-rated and may not be PG-13 or R. © 2021 Warner Bros. Entertainment Inc. All rights reserved.



SCAN TO SEE MORE



LOOK FOR IT ON 4K ULTRA HD™, BLU-RAY™ & DIGITAL

DAVID L. WOLPER PRESENTS "WILLY WONKA & THE CHOCOLATE FACTORY" SHAWN GENE WILDER
JACK ALBERTSON AND INTRODUCING PETER OSTROM AS "CHARLIE" WITH ROY KINNEAR, JULIE DAWN COLE, LEONARDO STONE, DENISE NICKERSON
ODD DENERY, PARIS THEMEN, WRITTEN BY ROALD DAHL, WITH "CHARLIE AND THE CHOCOLATE FACTORY"
WRITTEN BY LESLIE BRICUSSE, ANTHONY NEWLEY, AND WALTER SCHARF
PRODUCED BY STAN MARGULIES AND DAVID L. WOLPER, AND WRITTEN BY WALTER SCHARF



© 2021 Warner Bros. Entertainment Inc. All rights reserved.

PUT A PAUSE IN YOUR DAY

With so many demands from work, home and family, there never seem to be enough hours in the day for you. Why not press pause once in a while, curl up with your favourite magazine and put a little oasis of 'you' in your day.



PRESS PAUSE
ENJOY A MAGAZINE MOMENT

To find out more about Press Pause, visit:

pauseyourday.co.uk

MAXIMUM PC

EDITORIAL

Editor-in-Chief: Zak Storey,
zak.storey@futurenet.com
Staff Writers: Christian Guiton, Sam Lewis
Contributing Writers: Dave Alcock, Kris Buttenill,
Ian Evenden, John Knight, Jeremy Laird, Chris Lloyd,
Neil Mohr, Nick Peers, Jarred Walton
Copy Editors: Katharine Davies
Editor Emeritus: Andrew Sanchez

ART

Art Editor: Fraser McDermott
Photography: Olly Curtis, Phil Barker, Neil Godwin, Dave Alcock
Cover Photo Credits: Corsair, Oculus, Raspberry Pi Foundation

BUSINESS

US Marketing & Strategic Partnerships: Stacy Gaines,
stacy.gaines@futurenet.com
US Chief Revenue Officer: Mike Peralta,
mike.peralta@futurenet.com
East Coast Account Directors: Brandie Rushing,
brandie.rushing@futurenet.com
East Coast Account Director: Michael Plump,
michael.plump@futurenet.com
East Coast Account Director: Victoria Sanders,
victoria.sanders@futurenet.com
East Coast Account Director: Melissa Planty,
melissa.planty@futurenet.com
East Coast Account Director: Elizabeth Fleischman,
elizabeth.fleischman@futurenet.com
West Coast Account Director: Austin Park,
austin.park@futurenet.com
West Coast Account Director: Jack McAuliffe,
jack.mcauliffe@futurenet.com

Director, Client Services: Tracy Lam,
tracy.lam@futurenet.com

MANAGEMENT

MD Tech Specialist: Keith Walker
Group Editor-in-Chief: Graham Barlow
Group Art Director: Jo Gulliver

PRODUCTION

Head of Production: Mark Constance
Production Manager: Vivienne Calvert
Project Managers: Clare Scott
Production Assistant: Emily Wood

FUTURE US, INC.

11 West 42nd Street, 15th Floor, New York, NY 10036, USA
www.futureus.com

INTERNATIONAL LICENSING & SYNDICATION

Maximum PC is available for licensing and syndication.
To find out more, contact us at licensing@futurenet.com or
view our available content at www.futurecontenthub.com.
Head of Print Licensing: Rachel Shaw,
licensing@futurenet.com

SUBSCRIBER CUSTOMER SERVICE

Website: www.magazinesdirect.com
Tel: 844-779-2822
New Orders: help@magazinesdirect.com
Customer Service: help@mymagazine.co.uk

BACK ISSUES

Website: <https://bit.ly/mpcsingleissue>

Next issue On Sale July 20, 2021

© 2021 Future US, Inc. All rights reserved. No part of this magazine may be used or reproduced without the written permission of Future US, Inc. (owner). All information provided is, as far as Future (owner) is aware, based on information correct at the time of press. Readers are advised to contact manufacturers and retailers directly with regard to products/services referred to in this magazine. We welcome reader submissions, but cannot promise that they will be published or returned to you. By submitting materials to us, you agree to give Future the royalty-free, perpetual, non-exclusive right to publish and reuse your submission in any form, in any and all media, and to use your name and other information in connection with the submission.



Future plc is a public company quoted on the London Stock Exchange (symbol: FUTR)
www.futureplc.com

Chief executive: Zillah Byng-Thorne
Non-executive chairman: Richard Huntington
Chief financial officer: Rachel Addison

Tel: +44 (0)225 442 264



Zak Storey

LAKE OF ROCKETS AND STUFF

WE DID IT! We finally took new portrait shots for the mag. The beard is gone! OK, so I haven't had a beard for a long time, but that's beside the point—this was the first time we managed to slot in a portrait shoot in over a year, and it all happened because of one tiny mistake.

Our staff writer, Sam, embarked upon his first ever PC build this issue. I decided it was time to throw the boy in at the deep end, to get his toes wet in the murky system-building pools that are *Maximum PC's* mainstay.

As Sam lives so far away from the office, we decided it was best if he built the rig, took photos of what he wanted, then we would recreate that and shoot it professionally in the studio. Only problem was, he missed his delivery slot the day before. So at 5 a.m. on the morning of the shoot, he jumped in his car and drove for four and a half hours to get to the studio for the photoshoot. At which point I made him do a full day's work, stripping down and rebuilding the system—and we managed to fit in a few portrait shots while we were all there.

A good experience all around, I think. It's a kick-ass little gaming PC—it certainly looks good, and hopefully Sam's fresh-faced insight as a beginner should prove to those of you still on the fence about building your own PC that it's well worth it, and not too difficult.

I also decided it was time to take a look at where Intel is going. After all, it's hard to ignore that the company is on the back foot when it comes to processors right now, so Jarred's giving us the low-down on where Intel's been, where it's going, and just what it has up its sleeve to finally take the fight back to AMD.

On top of that, Ian's written a fantastic eight-page feature on getting started with Raspberry Pi, and our

prodigal son, Christian, has returned after beating the crap out of his health woes to take a look at the history of PC gaming. From *Pong* to *Portal*, it's well worth checking out.

For tutorials, we've got everything from developing design concepts to improving your VR setup to 3D-printing your own DIY reservoir holders, and, of course, a fan-favorite: John Knight's retro machine of the month.

The review section is also pretty daisy. Jarred told me we needed to review AMD's RX 6800 and Nvidia's GeForce RTX 3060 to round out our GPU coverage—so we have. We've got the latest Corsair One in, too, plus an epic 49-inch monitor from AOC, the most affordable VR headset to date in the Oculus Quest 2, a fantastic in-depth review of *Nier Replicant ver1.22474487139* (I'll never get tired of typing that one out), and our software head-to-head this issue takes a look at Tidal versus Spotify to see which is the music-streaming king.

Combine all that with a ton of columns from our regulars, including the Doc, Jarred, Christian, myself, and more, and an updated set of Blueprints to cry over, and it's a kick-ass issue, and one I'm sincerely proud of.

As always, stay safe out there! And I'll see you next time.

Zak Storey

Zak is Maximum PC's editor-in-chief and long-time staff member. He's been building PCs since he was 10, and is more than capable of butting heads with the biggest names in tech.

➤ submit your questions to: editor@maximumpc.com

THE NEWS

Bitcoin's Bubble

Cryptocurrencies are valuable, but dirty

BITCOIN NEVER seems to be far from the news, whether it's for startling rises in price, dramatic crashes, or both within days. It has always been an unstable creation, but the real roller-coaster ride didn't start until October 2020. Recently it has been particularly volatile; as we write, a coin is worth \$39,750, although it could be vastly different by the time you read this. Just within the last month, it reached \$59,000, and even hit over \$63,000 in April. Go back a year, and it was "only" worth \$10,000.

Predictions on where bitcoin will go next are pointless. Many maintain it will reach \$250,000 or more within the next few years, which would bring its value to that of gold. Others forecast a fall of equally dramatic proportions. In February, Elon Musk backed it, and said Tesla would accept it as payment for cars. The price duly jumped. In mid-May, he changed his tune, and

would no longer accept bitcoin, which prompted an equally sharp drop. Meanwhile, ethereum, the second biggest cryptocurrency, has surged. It started the year at \$730, and recently reached over \$3,000.



Dogecoin, publicly backed by Musk after he ditched bitcoin, has also enjoyed a spike. It was started as a joke, and a coin was worth a fraction of a cent in January. Now it's worth half a buck. Joke or not, some people just made a lot of money.

Good news for cryptocurrencies, you might think, but because there are no tangible assets, this trading in coins is speculative, with all the hallmarks of a bubble. The first of these was the tulip mania that overtook the Netherlands in the 17th century. At its height, one bulb of a rare variety would fetch 10 times the annual wages of a skilled craftsman. It all came crashing down, and tulip bulbs became what they always

were: nice flowers. No solid assets means we're building on sand. If the servers are switched off, you have nothing.

Cryptocurrency economics are equally bizarre—the value is measured against the cost of electricity to do the mining. As miners are rewarded in coins, the cost to produce each coin (excluding capital costs) is the cost of running the hardware to mine it. According to a new study by Cambridge University, bitcoin mining consumes 121 terawatt hours per year. To put that in perspective, bitcoin consumes more electricity than the Netherlands or Argentina.

This environmental aspect of bitcoin could be its undoing. Thousands of tons of fossil fuel are being burned to maintain something that, in essence, is worthless. The biggest miners are still in China (around 60–65 percent), and most of the mining is coal-powered. Even using renewable resources is hardly environmentally-friendly, merely diverting power from replacing fossil fuels elsewhere. Awareness of the profligate use of energy that mining entails is growing. Subsidies for using renewable power are being withdrawn,

and political opposition, while still nascent, is growing.

Perhaps of more immediate concern is the way the business sucks the best hardware out of the market. All those lovely GPUs live their lives running endless hash functions, sitting in racks in featureless sheds, when they should be in high-end rigs rendering games. Other shortages are being exacerbated by mining, too, including HDDs, SSDs, and memory chips (see page 13 for what chia could do for these).

All this computing power could be doing something useful, such as exploring the boundaries of quantum physics, weather prediction, researching superconductivity, or other such jobs to advance human knowledge. Virtually any other task would benefit the human race more. This vast resource is being used to make a few people rich, and nothing else.

There is a voracious appetite for cryptocurrencies, with over 4,000 of them in existence. The blockchain makes an excellent ledger, perfect for making international banking transactions, maintaining share ownership lists, or anything requiring a single secure ledger. As a method for pure financial speculation, its days may be numbered. The environmental angle may be one of the more convincing arguments for the market to shift to a more efficient and less resource-hungry model. We want our chips back. —CL



Cryptocurrencies make some rich, some poor, and quite a few annoyed, but it is the power consumption that may be their Achilles heel.



IRREPARABLE GOODS SLAMMED

FTC REPORT POURS SCORN ON THE EXCUSES MADE

THE FEDERAL TRADE COMMISSION has made its final report on manufacturer-imposed restrictions on the repair of hardware, and has concluded that things are

far from ideal. It has examined the reasons for the restrictions supplied by manufacturers and found that "the majority are not supported by the record." There are, apparently, eight main ways you are stopped from repairing things, from the requirement to use special tools, through to using soldered components and citing (non-existent) safety worries. Many of the problems are baked into the designs, and exacerbated by limited information. The worst offenders are the makers of smartphones, laptops, and cars. Apple received some special mentions, too, for ensuring that only Apple can fix its products. The FTC was pleasingly thorough in refuting manufacturers' excuses, and in its support for right-to-repair advocates. The conclusion is that the American public is not getting a fair deal, and the FTC has pledged to work with legislators to ensure you can fix what you buy, where feasible, without using OEM designated repair facilities. **-CL**

AMD AND GF FINALLY PART WAYS

The partnership that never really worked

AMD AND GLOBALFOUNDRIES (GF) have announced a change to the Wafer Supply Agreement (WSA), which removes all exclusive arrangements. GF was originally part of AMD; the split came in 2009, but AMD retained a third ownership. At first the pair were close, and AMD was to move most of its business to GF. But the two fell out, and AMD sold its interest in GF in 2012, so it could shop elsewhere. GF struggled to keep pace with AMD's technical developments. When AMD reached 14nm, production was licensed to Samsung. Since then, GF has been left making I/O and legacy chips. AMD moved to TSMC for 7nm and below, but was obliged to use GF for all 14nm business. This it no longer has to do, though it has agreed to buy a minimum number of chips until 2024. The two firms have had a rocky relationship: AMD has had to pay GF off more than once, and GF has been obliged to develop production capacity it can't easily re-use. The split is finally complete. **-CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

FIRST 2NM CHIPS

IBM has produced wafers with a transistor density of 333 million per mm², using "nanosheets."

PHOTOREALISTIC RENDERS

Intel has demonstrated a system that uses AI enhancement to render at "interactive" speeds. Results in *GTA V* are incredible.

OVERCLOCKING RECORD

Somebody has got Intel's new Rocket Lake Core i9-11900K to run at 7.14GHz on all cores using liquid nitrogen cooling. Result.

TRAGEDIES

XBOX LOSES MONEY

Microsoft has revealed that it has never made a profit from selling consoles.

CONFUSED BY CONES

Waymo's self-driving taxis can't cope with traffic cones; a car blocked the road and required rescue. Fully autonomous driving is still some way away.

FLASH TO BE KILLED

Windows is to finally kill Flash, with mandatory removal in a forthcoming update.



HACKERS CUT FUEL SUPPLY

Ransomware attack shuts essential pipeline

RANSOMWARE ATTACKS reached new heights in early May when hackers hit Colonial Pipeline and demanded payment for 100GB of stolen data. The company operates the biggest fuel pipeline in the country, running 5,500 miles from Houston in Texas to Linden in New Jersey. It supplies about 45 percent of the gas, diesel, and aviation fuel for the whole East Coast—over 2.5 billion barrels a day. It's not clear if the hackers had the ability to trigger dangerous events, but Colonial Pipeline had little choice other than to hit the "off" switch. This led to unscheduled plane landings to refuel elsewhere, panic buying, and a jump in gas prices. Colonial Pipeline also had little option but to pay—about \$5 million in bitcoin. Normal service (mostly) was resumed five days later.

Colonial Pipeline uses thousands of pumps, valves, and sensors, all connected to a central control. It has not been revealed how the system was compromised, but remote working is suspected. The group responsible has been identified by the FBI as going under the name DarkSide. The group was in it for money, rather than chaos, as it admits on its website. DarkSide originates from Russia or Eastern Europe, but claims to have no political motives. It has a history, though, with more than 40 confirmed previous victims. The FBI did manage to shut down the cloud system the hackers used to collect the data.

It was an attack on a critical part of the nation's infrastructure, highlighting the fragility of much of the world's systems. Hackers increasingly target industrial control systems, where the consequences, and rewards, are bigger. As the hackers operate from remote locations, often under disinterested governments, there's little you can do other than tighten security. A chilling reminder that future wars may include orchestrated cyber attacks on major infrastructure networks. **-CL**



Launch of lightweight OS delayed indefinitely

WIN10X WAS TO BE, essentially, Windows Lite. It was a cut-down, modular version intended for more limited hardware platforms, where Windows' increasingly bulky footprint would overwhelm the hardware. Basically, a rival for Chrome OS, which powers all those Chromebooks that cut into Microsoft's share of the laptop market. Win10X was first in revealed in 2019, and Microsoft teased us with the Surface Neo Duo and dual-screen Surface Neo, which required Win10X to work—neither arrived. Eventually the Surface Duo emerged, but Android-powered, and poorly promoted. Then Win10X was "refocused" to x86 hardware, ditching the idea of using sandbox containers to run other platforms. The market has swung to ARM-based designs more markedly since then. It also became clear that stripping Windows down to run on small devices removes much of what makes Windows so good in the first place.

Microsoft's attempts to get operating systems on devices smaller than a laptop have been notable for their lack of success. Remember the truly awful WinCE? At least it had an apposite name. Then there was Windows RT, Windows S, and Windows Mobile—all best forgotten. Microsoft should have bought Android (somebody is probably still kicking themselves over that lost opportunity), instead of spending hundreds of millions trying to fit Windows on to devices that were never intended to host it. Starting with code so integrated with x86 architecture for devices that aren't doesn't help. Full-fat Windows is what Microsoft does best; wasting vast sums to unsuccessfully compete in other markets is pure hubris.

Microsoft is to concentrate on the 21H2 update instead, complete with the Sun Valley UI update, with its new icons. Some of Win10X's UI tweaks are being ported across to the forthcoming update, so at least some work has been salvaged. The buzz is that Windows is to be "rejuvenated." Let's hope this is the last time Microsoft tries to foist Windows on to unsuitable platforms. —CL

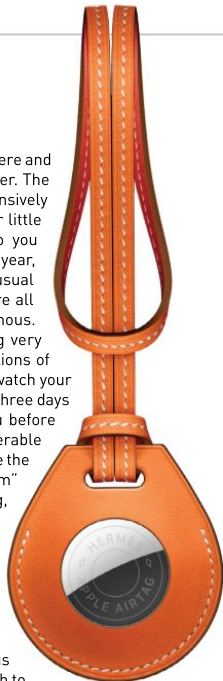
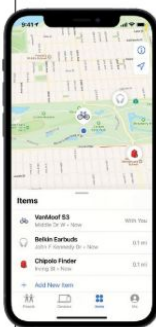
You've Been Tagged

APPLE'S NEW \$29 AIRTAG is a little button you can place anywhere and locate again via an app, thanks to a unique Bluetooth identifier. The range is about 30–300 feet. If your AirTag is more comprehensively lost, you can put it into Lost Mode, and anybody pinging your little friend sees a message from you, and contact details, so you still might get your keys back. The battery lasts about a year, but it's a regular CR2032 and easy to change (so not the usual Apple nightmare). The Bluetooth IDs and phone locations are all uploaded to Apple's servers, but it's all encrypted and anonymous.

So, what's the problem? Firstly, it makes covert tracking very easy and cheap. Secrete an AirTag somewhere, and the millions of Apple devices will co-operate in the surveillance, while you watch your target wander around a map on the app. Apple sets a limit of three days on how long an unknown AirTag can sit within range of you before it warns you of its existence. Long enough to gather considerable information. Once warned, you can find the AirTag, and remove the battery if you are concerned. If your "victim" doesn't have an iPhone, there is no warning, of course. Soon after AirTag's release, the experiments started, as people covertly tracked each other, parcels in the mail, and cars. It proved worryingly easy.

The chips inside the AirTag aren't hard to reprogram either. Lost Mode can be diverted to the URL of your choice, turning the AirTag into a booby-trap to malicious websites. Apple prides itself on its approach to privacy, and AirTag is a good idea if used properly. However, Apple has released a cheap, mass-produced, passive, anonymous tracking device, which will be misused. —CL

Left: Apple's AirTag turns every iPhone into a network to track its location. **Right:** Apple AirTag Hermès charm.



M2 Chips This Summer

Apple's M2 chip is on schedule to make its debut inside a 16-inch MacBook Pro this July, and in other high-end Macs in the fall. Apple said it would take around two years to move to the new ARM-based silicon, and is on track to do it faster. Rumor has it that the M2 will have 12 CPU cores, eight high-power and four low-power. The graphics core count doubles to 16, giving gaming a considerable bump. It is being built by TSMC using its N5P process, said to offer around 10 percent better numbers than the regular 5nm process. The M1 impressed us all, and gave the x86 world something to chew over; the M2 manages the same trick higher up the tree. The question is: Will it be good enough to tempt system builders to use M2s in Windows rigs? —CL

New Magnetic Tape

As part of the quest to build a commercially viable fusion reactor, a team at Commonwealth Fusion Systems has developed a new type of high-power magnet, made using multiple layers of tape containing barium copper oxide, which, when cooled to minus 253 C, becomes superconducting. This is very cold, of course, but in the world of superconductivity, it's practically warm. The magnetic tape has taken decades to develop, and means considerably less complex refrigeration is required. An experimental fusion reactor is to be built in Massachusetts that uses 18 10-ton versions of the new magnets arranged into a tokamak, a torus-shaped ring that creates a magnetic field to contain the plasma as it is heated to tens of millions of degrees. —CL



Jarred Walton

TECH TALK

Goodbye Mining, Hello Farming

JUST WHEN YOU THOUGHT the cryptocurrency-induced PC component shortages couldn't get any worse, there's a new coin in town: chia. Try to ignore the catchy "ch-ch-ch-chia" jingle in your brain and focus on the looming prospect of a cryptocurrency that does to storage what ethereum has done to the graphics card market. By the time you read this, it's entirely possible the storage shortage (stortage?) will be well under way.

Chia coin officially went live on March 19, but the coin didn't start publicly trading on crypto exchanges until May 3. From a slow burn for the first few weeks, the amount of storage space required for the network (called netSPACE) ballooned from around 214PB to over 3.6EB—that's exabytes, or 3,984,588.8 terabytes. I shudder to think about how much netSPACE will be allocated to chia by the time you read this, given the current rate of increase.

But let's talk about what makes chia different. One of the big concerns with bitcoin, ethereum, dogecoin, and many other crypto coins is that they rely on proof of work. It's a race to solve a mathematical function that scales in difficulty. Bitcoin uses an estimated 13GW of power, or 14TWh per year—about as much as the Netherlands.

Chia, in contrast, uses proof of time and space, which should dramatically cut down on the amount of power consumed. On the other hand, it will chew up as much storage space as people are willing to throw at it, with a current default plot size of 108.9GB. Using 10TB hard drives, it would require about 360,000 drives for the current netSPACE. Assuming 5W of idle power use (the drives would mostly be idle), that's still 1.8MW of power, so bitcoin currently uses over 7,000 times as much energy. But if the netSPACE reaches 30EB or even 300EB, suddenly chia stops looking so green.

The proof of space element should slow down the rate of scaling. Where all that's required to bring a new GPU or ASIC online with proof of work hashing is powering the device up to start "mining," chia refers to its proof of space as "farming." Chia farmers have to generate plots that get filled up with what amounts to a complex bingo card. This takes a fast PC using a fast SSD about four hours



Chia promises an eco-friendly approach to crypto—by gobbling storage.

for a single plot, but with the right hardware, it's possible to do a dozen plots concurrently in about eight hours. That means even if a big mining corporation wants to hop on the chia bandwagon and buys a few petabytes of storage, filling those drives up with chia plots could take several weeks.

Maybe it will end up as another flash-in-the-pan cryptocurrency. That's perhaps the best-case scenario. The worst-case scenario has started to play out in China, where SSD and HDD shortages are already happening. One SSD manufacturer attributes a 500 percent increase in sales in April to the demand from chia farmers, for example, and people online have reported seeing 400 percent

increases in large HDD prices virtually overnight.

If you're thinking about joining the chia farming club, we might see 10TB hard drives selling for \$500 or more, compared to a previous price of \$200. That will impact people who aren't trying to farm chia as well, and with SSD controller shortages prior to chia, we could see another perfect storm hit the PC industry—this time hitting HDD and SSD markets rather than GPUs. With a current price of around \$1,000 per XCH (chia's coin abbreviation), we might be in for more turbulence.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

Join the conversation!



Discuss all things PC gaming with fellow
readers at our official forums
forums.pcgamer.com

PC GAMER



Christian Guyton

TRADE CHAT

Tech Is Everywhere; Why Are Hospitals So Behind?

I'M BACK. I was diagnosed with lymphoma in December, and had to take time off while undergoing chemotherapy. Things are looking up now, but I spent a lot of time in hospitals over the last few months, and it left me wondering why the medical industry is so far behind with its computing.

I was transferred to a cancer unit at a different hospital halfway through my treatment. The new location was much more modern than the previous hospital, with all manner of high-tech, squeaky clean medical equipment. Even my IV drip had a touchscreen display. Nurses used modern (if budget) tablets to input patient details. One specialist administering my antibody injections told me with mild excitement that their department had recently upgraded all of its tech hardware.

After seeing all this, I was surprised to sit down with my clinician for an appointment and watch him boot up Windows XP on a chunky tower PC bearing the unmistakable logo of AMD's aging Athlon II processors. The hardware issue I understood; hospital funding is often tight, and buying every doctor a new desktop every few years would be a big ask. I asked if he was allowed to upgrade to Windows 10 and he told me that hospital staff had requested it, but management wasn't interested.

This got me thinking. Computers are used for a vast variety of purposes within the medical field: storing confidential information about patients, maintaining interdepartmental contact, video calls. Staff often use medical cart computers, which are essentially small workstations on wheels. Every hospital has to be propped up by an IT team, along with numerous admin employees who use computers daily.

I decided to do some research, to find out if there was a root cause behind the medical industry's failure—or refusal—to move with the times. It isn't

as though computing is new to the field; even as early as the 1970s, the notion of using computers to store patient information was already established.

Surely, I thought, staying up to date with technology would streamline many aspects of the medical profession? Surely staying ahead of the curve would offer greater digital security for the millions of patients whose private medical data was being held by hospitals and insurers across the country?

So, was my doc's use of XP an outlier? Sort of, but what I found when I went looking didn't fill me with confidence. A 2020 study of 1.2 million devices by cybersecurity firm Palo Alto Networks concluded that as much as 83 percent of the computers in use by medical professionals in America were running outdated, unsupported operating systems, such as Windows 7, XP, and old Linux builds. Just 11 percent of the surveyed devices were running Windows 10.

I learned that a major hurdle to healthcare groups updating their computers is the amount of specialist software used by



Outdated software costs healthcare workers precious time every day.

hospitals and doctors' offices. Upgrading to a newer OS could risk incompatibility, hamstringing programs vital for treating high-risk patients. Such overhauls have to be widespread, too, or they lead to complications in sharing information between employees.

Eventually, the healthcare industry will be forced to catch up. New software isn't being ported wholesale to Windows XP, after all. But will hospitals leap forward to more modern horizons and then keep the pace, or start to fall behind again immediately? I very much hope it's the former, but I suspect the latter is more likely.

Christian is a game lover and hardware enthusiast, always seeking new tech. Follow him on Twitter: @GuyFromMaxPC.



83 percent of computers used by US medical professionals were running outdated OSes.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

- > PC Shutdown Woes
- > Zoom Black Screen
- > RAID in Cockpit

PC Won't Stay Off

Hi Doc, I've built around 30 PCs over the past 20 years but have never seen this before. I recently built a new PC with Windows 10 Pro and all updates installed. My build: Gigabyte x570 PRO WIFI, Ryzen 5 5600X, 32GB RAM, 2TB MP600 NVMe SSD, RTX 3070 graphics, and EVGA BR600W PSU.

If I click "Start → Power → Shut down," the computer simply restarts. I've searched online, tried everything in Windows, including turning Fast Boot off, but nothing works. The only way to switch off my PC is to hold the power button for a few seconds for a forced shutdown. Obviously, I'd really like to resolve this problem and be able to do a Windows shutdown the normal way. Any help would be great.

—Joel Briere

THE DOCTOR RESPONDS: Joel had already anticipated our first suggestion—making sure the automatic restart option is disabled when Windows blue-screens—so we next asked him to check Event Viewer for any potential clues. To open it, type "event" into the Search bar and click "Event Viewer." After a short pause, you'll get

a summary of events by type, including Critical, Error, and Warning. Again, Joel reported no errors relating to reboots could be found.

At this point, we decided to run with the idea that Windows might not be the problem, but that the hardware was somehow involved. We widened our search to see if other X570 boards were exhibiting similar symptoms, and discovered a combination of Windows and UEFI settings that fixed Joel's problem. Simply put, by re-enabling Fast Boot in Windows, but disabling Fast Boot and Wake on LAN in the UEFI, Joel was able to get his PC to shut down properly at last.

CPU Not Supported

Recently, program updates have failed with the error "CPU is not supported." Ten years ago, I cobbled together a DIY system based on a quad-core Intel Core i7-875K (2.93GHz) on an Asus P7P55 LX motherboard, 8GB RAM and an AMD Radeon HD 5800 series graphics card rounded it out, and over the years a 500GB SSD, 5TB hard drive, and a replacement fan or two have maintained the system performance through

clean installs of Windows 7, 8, and 10 Pro.

Now the CPU support issue is preventing updates to VMware, some Zoom add-ins, and my go-to movie creation/editing application. The question is, can I get by with just a CPU update, or is a new mobo needed?

—Alan Keyworth

THE DOCTOR RESPONDS: It looks as if your CPU has come to the end of the road, and likely the rest of your system too—at least for these specific apps. You might be able to "trick" VMware into bypassing the CPU check during the upgrade process using an "allowLegacyCPU=true" flag (see <https://bit.ly/3y0ENv6> for full details and why it's not a long-term solution).

The age of your system means a simple CPU upgrade won't cut it—it's time to bite the bullet and look for a new system, basically a motherboard, CPU, and RAM. You can, of course, source these separately, but in 2021 even a budget system will outperform your formerly state-of-the-art rig. The Core i7-875K scores 3,127 on Passmark's CPU benchmark—the mid-range

Core i5-10400 has six cores (12 threads) and scores 12,436 in comparison.

You can get an 8GB Core i5-10400 box (Acer Aspire TC) for under \$500 on www.newegg.com but, of course, if you can afford better, use Google to perform some comparative benchmark searches along the lines of "i5-10400 versus i7-875K" to see what's out there based on your budget.

Black Screen in Zoom

Doc, as a music teacher, I spend a lot of time on Zoom and sometimes I need to share my screen. Problem is it doesn't always work. When it doesn't, the students I'm working with see a black screen that only displays my cursor, which they can see move. Also, if I open menus while sharing, that can be seen too as a change in texture. One day I got a black screen when trying to share my AOL desktop, but it worked fine when I switched to sharing Sibelius. My specs are: AMD FX 9590 CPU, Gigabyte 90FXA-UD3 mobo, 16GB of DDR3 RAM, and an AMD Radeon R9 200 with a Sept 22, 2020 driver running Windows 10. My version of Zoom is up

↘ submit your questions to: doctor@maximumpc.com



THE ROCKET LAKE GAMING PC

Sam Lewis has to fend for himself with his first ever build for *Maximum PC*

PC BUILDS are second nature to us here at *Maximum PC*, as you know. We thrive on crafting the finest machines each month, pushing ourselves to the limit to create a build to a specific brief, and challenging ourselves to make a work of art. So, what happens when you put a PC newbie at the helm of a build? Well, you get there slowly. And our journey wasn't plain sailing. Copious amounts of head-bashing, hair-pulling, shouting, and taking parts out and putting them back in took up 99.9 percent of the time spent on this month's build. Our writer, however, has emerged from the experience with knowledge that will stay with them for the rest of their PC building life. The knowledge of what goes where, how to fit everything together, and the importance of practice and an abundance of patience will stay with them forever.

Our photographer, Olly, should thank his lucky stars that he was even able to see the build, let alone photograph it. This was the one time our courier wasn't late, and the one time we didn't want it to be punctual. The build wasn't quite completed in time for collection, and with a tight next-day photography session booked, there was only one way to make it there. Our unfortunate writer decided to wake up at 5 a.m. and drive 4.5 hours to our studio to hand-deliver it. If he doesn't make it in this industry, he'd make a cracking delivery driver. With everything done in the nick of time, we can now get into the build and how it all went down.





ROCKET LAKE PC INGREDIENTS

PART		RRP	STREET PRICE
CPU	Intel Core i9-11900K	\$550	\$550
GPU	MSI GeForce RTX 3070 8GB Gaming X TRIO	\$800	\$1,239-\$2,500
RAM	16GB (2x 8GB) Corsair Vengeance RGB Pro SL DDR4-3600	\$110	\$122
Mobo	MSI MAG Z590 Tomahawk WiFi	\$285	\$285
OS Storage	1TB Samsung 970 Evo Plus M.2 PCIe 3.0 SSD	\$160	\$150
PSU	750W Corsair RM750x 80+ Gold Modular	\$135	\$135
CPU Cooler	Corsair iCUE H100i Elite Capellix 240mm AIO	\$160	\$160
Case	NZXT H510 ATX mid-tower chassis	\$70	\$70

TOTAL

\$2,270 OR \$3,972

ROCKET LAKE INGREDIENTS



CPU

INTEL CORE I9-11900K \$550

It may not have the most cores out there, and it might not be the fastest desktop processor around, but this is the best that you can get from Intel right now, and it still packs one hell of a wallop. With eight cores, plus 16 threads of pure backported 14nm performance, it's a monstrous achievement, and credit where credit's due, it still manages to keep up with CPUs of half its transistor size. Aside from that, it also comes with support for PCIe 4.0 drives right out of the gate, packs in a hefty max turbo speed of 5.3GHz, and actually boasts some rather impressive integrated graphics. You know, for when you sell your GPU to buy your next house. It's also, more importantly right now, in stock, making it a valuable asset for anyone looking to actually build a modern-day gaming PC. www.intel.com

GPU

MSI GEFORCE RTX 3070 8GB GAMING X TRIO \$800

The MSI RTX 3070 is a tale in itself. It started out life as an amped-up RTX 3070, with a recommended retail price \$60 higher than its namesake—nothing out of the ordinary there. It jumped up to \$569 in December, and it now has an RRP of \$800. That's a price bump coming direct from MSI, and it shows how the silicon shortage is starting to affect manufacturers, too. We're hearing multiple reports of wafer prices increasing dramatically, pushing extra costs on to the manufacturing side of things. That aside, the RTX 3070 is fantastic for 1440p, 120Hz gaming and beyond, and the Gaming X Trio provides an epic cooling solution. If the prices return to a normal level (near the original \$560 mark), consider picking one up. Just don't pay the street price. www.msi.com



MSI MAG Z590 TOMAHAWK WIFI \$285

If you're running the latest-generation Intel processor, it's highly recommended you grab one of the latest boards, too. Z590 is a big part of the Rocket Lake appeal in our eyes, and well worth the investment, unless you already have a fairly high-end Z490 board at your disposal. The increased DMI, native support for PCIe 4.0, and expanded Wi-Fi connectivity will help a ton in the long run. Our MAG Z590 solution here might be pricey up front, but you get a 2.5G Ethernet port, support for Wi-Fi 6E, excellent power delivery, a comfortable amount of USB and onboard connectivity, and a super-slick design, with integrated rear I/O shield, and plenty of shine on top. www.msi.com



16GB (2x 8GB) CORSAIR VENGEANCE RGB PRO SL DDR4-3600 \$110

Memory can be a little tricky to choose. We've seen a slow increase in RAM prices over the last year or so, but nothing quite like the boom in other components, 7nm or otherwise. We've decided to opt on the side of budget for this build, however, and grab a 16GB kit of Corsair Vengeance RGB Pro SL, running at 3,600MT/s, with a CAS latency of 18. It's a new product, launched earlier this year from Corsair, and it comes with some updated lighting and better overall performance. 3,600MT/s might be a touch excessive, given that Intel is not quite as dependent on memory speed as Ryzen, but for rendering applications and light Photoshop work, it'll help out significantly. Is 16GB enough, though? Well, it depends on your personal computing habits. If you're a minimalist and like to keep your desktop clean and workspace mostly empty, then it's going to be plenty. However, if you need to have 32 Chrome tabs, Discord, Slack, Google Chat, 28 other background programs, and the latest AAA title all running at the same time, then opting for the slightly more expensive 32GB kit might be a better choice. www.corsair.com

PSU

750W CORSAIR RM750X 80+ GOLD MODULAR \$135

We're keeping things simple for our power supply and going with a fully modular 80+ Gold solution from Corsair. Its RM series of power supplies has long been a favorite across the PC-building community, and with good reason. With a fantastic 10-year warranty and excellent noise characteristics, along with modular cables, it's a mainstay among enthusiasts on a budget. Corsair's latest 2021 edition features updated internals, better temp management, a magnetic levitation fan, and some impressive load temps, too. We expect this rig to pull around 475W from the wall, meaning even under extreme load conditions, fan noise should be kept to a minimum, thanks to some zero fan tech. The only thing we'd change about this setup in hindsight? Maybe some custom cables, too. www.corsair.com



CPU COOLER

CORSAIR ICUE H100I ELITE CAPELLIX 240MM AIO \$160

In this build, we've gone with a trusted favorite of ours for the CPU cooling duties, namely the iCUE H100i Elite 240mm Capellix from Corsair. This wee beastie is the latest from the Californian giant, and packs in a slim rad, a set of hefty aRGB fans, and a kick-ass Capellix LED-lit waterblock. These things are

bright—seriously bright—and super-small, too, giving your cooler some extra pep and helping turn it into the centerpiece of your build. We'll be running this at the front of the case, with our fans in a push configuration, drawing cool air in the front, then exhausting it out of the back. By default,

the H100i Elite supports pretty much every major socket type from both AMD and Intel, and comes in at a fairly reasonable price, too (given the silly LEDs sitting in the middle). You can also swap out the CPU block plate for an included white one instead if the stock style isn't quite for you. www.corsair.com





1TB SAMSUNG 970 EVO PLUS M.2 PCIe 3.0 SSD \$160

We've gone fairly minimalist with our SSD pick, with a single 1TB M.2 PCIe 3.0 SSD: the Samsung 970 Evo Plus. The reason we've picked this over its 980 Pro PCIe 4.0 cousin is twofold. Firstly, we're rather worried that by the time you read this, chia coin and its SSD-dependent farming will have hit the market hard (hopefully not, but there's no way of knowing), and if that's the case, this particular drive may still be readily available, or more so than its speedier cousin, at least. And secondly, it's slightly cheaper now, too—\$50 cheaper, in fact. As our primary aim here is a gaming PC, 1TB of PCIe 3.0 storage will be more than enough for quick load times. However, if you can stump up the extra cash, and it is in stock and not being farmed out for more non-physical currency, grabbing the 980 Pro would definitely be a better bet. www.samsung.com

NZXT H510 ATX MID-TOWER CHASSIS

\$70

Cheap? Cheerful? Actually, the NZXT H510 is one of the best budget chassis out there, and calling it anything else is insulting to this kick-ass low-cost case. ATX by design, this clean-looking mid-tower features a full-size PSU cover, intuitive cable bar, tempered glass side panel, and support for some decent cooling. It even comes with USB Type C support on the front I/O, and some awesome cable management solutions in the rear of the case, along with support for multiple 2.5-inch SSDs, and a hard drive bay for some 3.5-inch drives, too. It might not be as flashy as the H510 Elite, but then that's comes in at over twice the cost of this beauty for a very similar internal design. The only downside? Airflow isn't amazing, so over long periods of time, this machine could get a tad toasty. We recommend swapping out the two included case fans in the long term for something with a bit more grunt.

www.nzxt.com



BUILDING THE ROCKET LAKE

You can't go wrong with a white, black, and RGB color scheme

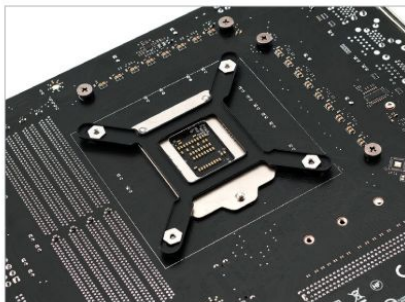
LENGTH OF TIME: 2-3 HOURS LEVEL OF DIFFICULTY: MEDIUM



1

FIX THE CPU COOLING BRACKET

AN ODD STARTING POINT, but regardless of what you're building, it needs to be secure. Thankfully, that's one thing our writer knew before starting. For this PC, we need to start on the back of our motherboard by screwing in the liquid cooler CPU mount. It can be tight inside the chassis, so be careful moving things around, take your time, and treat everything delicately. Lay the bracket on a table and gently align it with the four screw holes around the CPU slot. With the correct stand-off screws that come with the Corsair cooler, secure the bracket in place for later. With the back of the mobo prepped, we can turn our attention to the brain of the build: the CPU.



4

MOTHERBOARD MOUNTING

WE HAVE TWO STICKS of RAM for this build, which means one thing: We can't just throw them in and hope for the best. There are specific slots that you need to use first if you are only using two. Look inside the motherboard's instruction manual to find out which slots you should use. For our build, it was the far-right and the second from left slots that we needed. Before placing the RAM in, make sure the clips on each end are opened. If not, push the edges of these down to open up the DIMM slots. Then take your DDR4 RAM sticks and look at the pins; you should notice an indentation along the bottom that determines how they fit. Align this indentation with the socket, and push it into place. A satisfying click tells you that your RAM is now snugly in place.



2

INSERT THE BRAIN

WHEN HANDLING Intel CPUs, it's important not to touch the bottom pins. Lightly pinch the sides when placing it in the motherboard. To begin, raise the retention arm. When looking at it straight on, you have to push this outward first to unhook it, then lift the arm to reveal the socket. Leave the plastic cover in place. Thankfully, on our Intel Core i9-11900K, one of the corners has an arrow that needs to align with a corresponding arrow on the mobo in order to position the CPU properly in the socket. This is the brain of the build, so take your time, don't apply any pressure, and it should all fall into place. Pull the retention arm down again slowly, so the bracket sits under the Torx screw, then push the arm back securely into the hook. Once done, the plastic cover pops off.



3

SSD STORAGE

WHAT'S A BRAIN WITHOUT MEMORY? We're talking SSD, not RAM. We'll get to that shortly. Our 1TB M.2 Samsung SSD will store everything in this build. Luckily, the MSI motherboard is labeled. Find the cover that has "M.2" written on it, and unscrew it. With the top facing you and the contact points to the right, we need to slot the drive into the M.2 port first. At a 30-degree angle, slide the drive in, then rest the SSD cutout above the screw hole. Secure this with one of the tiny M.2 screws, and your SSD is in place. Now to cover and protect it. Beneath the cover is a thermal pad, perfect for heat dissipation. Peel the protective layer off and align the cover over the screw holes, then secure it on top. Our SSD is now in place, with its sunscreen on, and is ready to hold all the 1s and 0s.



5

INSTALL CPU PUMP AND MOBO

NOW WE HEAD BACK to the CPU and mounting bracket as we are about to install the first part of our CPU cooler. Our Corsair iCUE H100i Elite came with the correct Intel bracket attachment pre-installed on the pump. Attachments for AMD chips were also supplied. There was also a white replacement cover for the pump, so we swapped that over to match our case. The pump mount has a plastic cover we have to take off, with pre-applied thermal paste on the copper side. Align the screw holes and put the pump on top of the CPU, making sure the CPU pump hoses are coming out the correct side. These need to go toward where our fans will be. Slot the motherboard into the case with the pre-installed I/O shield on the board going in first. Now screw in the board.



6

KEEP IT COOL

ALONG WITH THE EXHAUST FANS that come with the NZXT case, we have two Corsair fans for intake flow to attach to our radiator. The case doesn't have a front vent, just a side vent, so we won't be able to see them from the front. Remember, faces suck, so we need to keep the fan's faces pointing outward for effective air intake. The case comes with a bracket that goes between the radiator and the fans. With eight long screws and washers, this stage can be awkward, so we rested the radiator on top of the case and laid it down to make life easier. Make sure the radiator hoses are toward the top of the case, to ensure there's enough room for the behemoth GPU. Also, for cable management purposes, run all the cables to the back of the case for now, for installation later.



7 FAN CONTROL

BEHIND ALL THE PARTS at the front, we have madness at the back. As we have just fed the cables from the fans to the rear, we can now connect them to the Corsair iCUE Commander Core. This is the fancy box that will control all our RGB fans. We stuck a 3M sticky-backed tab to an empty panel on the back of the PC, and connected up the fan, RGB, and CPU pump cables. The RGB cables are at the top of our Commander Core unit and the fan cables connect to the bottom. By routing them through the back, we ensure that the front looks tidy. While doing this, we also inserted the CPU pump cable into the CPU fan socket, as we didn't do this earlier. The last step here is to connect the Commander Core to the power supply. With this Core, you can add up to six fans with RGB support.



8 POWER SUPPLY CABLES

TO AVOID ANY MESS at the front, we decided to insert the power supply cables into the motherboard first, then we routed them to the back. The first one we worked on was the big daddy: the ATX 24-pin. As the name suggests, there is a 24-pin connector on the motherboard to the right of the RAM slots. We slotted this in behind a panel to the right of the 24-pin connector—this cable splits into two, which we will insert into the power supply later. The next cable we have to deal with is the PCIe. Because this is for the GPU, we will rest this at the bottom of the case, ready to connect when the card is in place. To get power to the Commander Core, we need a SATA power cable; luckily, this can hide in the back of the case, so we stick this in and leave it toward the back.



11 CASE CABLES

BEFORE WE FIT the GPU and run out of room, we need to attach the remaining case cables to the board. First, take the exhaust fan cables to the back of the mobo for better cable management, and bring them in where the PWM connections are. We connected ours to the top-right of the mobo, in two system fan ports. These PWM connectors are delicate, so line them up, and connect them slowly. Following the NZXT instructions, we inserted the rest of the cables for the front-panel switches. Check your motherboard manual to match up the header connectors.



12 GPU TIME

WE'VE SAVED the best till last with this build: the graphics card. Seeing as the MSI RTX GeForce 3070 is pretty big, to say the least, it's the last chunk of metal to go into this case. Like the RAM, it can only go in one way. First, remove the two PCIe cover slots at the back of the case that align with the GPU PCIe slot. Pull the clamps down on the PCIe slot and click the graphics card into this port. Once in, screw it into the rear of the case. Next, attach the two eight-pin PCIe cables to the front of the GPU and run the cable out through the bottom and into the power supply. We don't have a fancy alternative PCIe cable here, unfortunately, and the provided cables tend to look a little messy.



9

A HELPFUL TIP

YOU THOUGHT WE FORGOT, but we didn't—the final power supply cable to connect to the motherboard is the CPU cable. Most are located in the top-left corner of the board, which is annoying. It's tight to bend a cable in the top and fit it around the back, especially as there is an exhaust fan pre-installed. With only four screws holding it in place on the top, removing this temporarily is a quicker and easier method than painfully trying to fit the cable through a cramped area. All the power supply cables have a clip on the connector so you can get it in the right way around and secure it in place. These are chunky cables, so be careful feeding them through, and be sure not to bend any pins on the motherboard.



10

POWER, POWER, AND POWER



ALL OF THESE CABLES need to go somewhere from the motherboard: into the power supply. The basement of the case is a great place to store all of the cable madness. Out of sight, out of mind. Kind of, anyway; just make sure the cables are not caught or squashed, and you'll be just fine. The cables clip securely into the power supply in the matching ports. When this is all connected, it's time to screw the power supply into the chassis. With four screws at the rear, this is easily done. One important factor is to have the fan facing downward, because with the tall feet on this build, it should have good air circulation. Be careful not to have your rig sitting on a carpet; breathing isn't only important for us.



13

POP THE PANELS IN

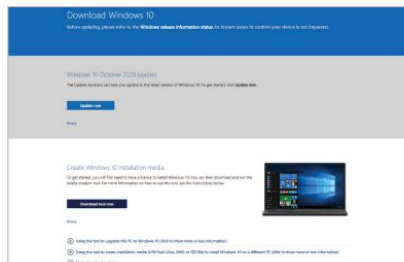
WE'RE ON THE last stage now (physically, anyway). Take the solid side panel and slot it into place, securing it with thumbscrews. The same goes for the front tempered glass panel: Slot it in and tighten those screws. The case is done. The PCIe cable that came with our power supply isn't exactly pretty and is pressing up against the glass; something to look out for next time. Now everything is in place, it's time to boot up. With a sigh of relief, an explosion of RGB bursts into life inside the NZXT case.



14

WINDOWS INSTALLATION MEDIA

NOW WE'RE ON TO A STEP that we all have to do with every new build. You need another PC at hand to open the software and a USB stick of at least 8GB. Head over to Microsoft's website and search for "Create Windows 10 installation media." Download this file, open up the software, and you will see a screen that says "Getting a few things ready." Accept the terms and conditions, and wait again. After the second time, it gives you the option to "Upgrade this PC now" or "Create installation media for another PC." Click the second option and proceed. On the next screen, leave things as default, and then you can choose which media to install Windows on to—click "USB flash drive," find your drive, and click "Next." It then starts to download.



15

16

The screenshot shows the AMD website's support page for Ryzen Desktop V-Series processors. The page has a dark theme with a large image of a Ryzen processor at the top. Below the image, there's a section titled 'Support for AMD Ryzen™ Desktop V-Series' with a sub-header 'Ryzen™ Desktop V-Series'. A red button labeled 'Support Center' is visible. The main content area is divided into sections for different processor types: Ryzen™ 5, Ryzen™ 7, Ryzen™ 9, and Ryzen™ Threadripper™. The 'Ryzen™ 5' section is currently selected and highlighted in red. It lists two processors: Ryzen 5 3600 and Ryzen 5 3600X. Each processor entry includes a table with columns for Processor, Processor Type, TDP (W), and Price (USD). The Ryzen 5 3600 is listed with a TDP of 65 W and a price of \$199. The Ryzen 5 3600X is listed with a TDP of 65 W and a price of \$249. Both processors are marked as 'New' with a red 'N' icon. The page also includes a sidebar on the left with navigation links: Product Center, Support, Ryzen™ Desktop V-Series, Ryzen™ Threadripper™, Ryzen™ 5, Ryzen™ 7, Ryzen™ 9, and Ryzen™ Threadripper™ Pro. The top of the page features the AMD logo and a navigation bar with links for Home, Products, Support, and About AMD.



- 1 If we did this build again, we would swap the fans and the radiator around, so that we could actually see the fans in the PC.
- 2 Unfortunately, our GPU bracket isn't compatible with our setup, hence why it looks like a skate ramp.
- 3 We changed out Corsair's black CPU pump cover for the white one provided in the box, for consistency.
- 4 Two more sticks of RAM could have improved this build's look and performance....

positive for the latest chip. It also wins on the 3DMark: Fire Strike benchmark, with a performance increase of 15 percent. Sure, our MSI GeForce RTX 3070 8GB Gaming X TRIO plays a role in this, but with the RRP in mind, it's a big difference.

Where the rendering machine reels some points back in is with the CrystalDisk read and write tests, and the Fryrender benchmark. Saying that, the results were not too far off at all—with a PC that can render nearly as well but can game a lot better, our build seems like a good path to go down. In Cinebench R15, the multicore index score was down by 7 percent compared to the rendering PC, but it beats it on the single-core index by 12 percent.

FINAL POINTS

Both machines are more than capable for a multitude of purposes, but we are glad to see how well our new mid-tower yacht looks and performs. With gaming coming in comfortably over the 60fps target and decent rendering speeds, too, it seems like a great all-arounder. This PC also sails along quietly, which

is always an added benefit. To improve the build, two more sticks of the Corsair Vengeance RGB Pro SL DDR4-3600 RAM would be nice. Also, if we could have replaced the stock exhaust fans with the same Corsair ones we have up front,

that would have helped with aesthetic consistency. Overall, for a first build, it was challenging, but it proves that you shouldn't be afraid of starting custom PC builds—this new kid on the block certainly had an enjoyable experience. ⚡

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Single (Index)	225	251 (12%)
Cinebench R15 Multi (Index)	2,590	2,413 (-7%)
Fryrender (m:s)	01:16	01:32 (-21%)
CrystalDisk Sequential Read (MB/s)	3,352	2,721 (-19%)
CrystalDisk Sequential Write (MB/s)	2,961	2,769 (-6%)
3DMark: Fire Strike (Index)	23,159	26,706 (15%)
Rise of the Tomb Raider (fps)	69	103 (49%)
Total War: Warhammer II (fps)	65	75 (15%)

Our zero-point consists of an Intel Core 10900K, 32GB (4x 8GB) Corsair Dominator Platinum RGB White @ 3600, a Zotac Gaming GeForce RTX 2080 Super AMP Extreme, and a 1TB Corsair Force MP510 M.2 PCIe 3.0 SSD. All game tests were performed at 3440x1440 on ultra.

UNPACKING INTEL'S ROCKET LAKE AND BEYOND

After the Rocket come the Alders, Raptors, and Meteors

After gazing into broad wells, we've scoured the skies, poked at the kabies (whatever those are), drunk plenty of coffee—in two flavors—then returned to our celestial beginnings with comets. And then there were rockets. If that's as clear as mud, we're talking about the past seven generations of Intel desktop processors, all of which have one thing in common: They're manufactured using a variant of Intel's 14nm process technology.

Granted, today's 11th-gen CPUs, aka Rocket Lake, have about as much in common with the 14nm lithography of Broadwell and Skylake as the latest SpaceX vehicles have in common with the space shuttle,

but that's a long time for a company that used to pride itself on alternating between new architectures and die shrinks every year. So, we're peeling back the heat spreader and digging into the underlying architecture to find out what makes Rocket Lake tick. Or is it tock?

Intel isn't done yet, either, and much as Broadwell for desktops was quickly kicked under the rug to make way for Skylake in 2015, there are promising future CPUs coming down the Intel pipeline. We'll discuss what we know of Alder Lake and the upcoming 12th-gen CPUs, and even look at what lies ahead. So, latch your helmet, strap in, and let's shoot for the moon. —JARRED WALTON



BACKPORTING ROCKET LAKE

To understand Rocket Lake, we need to go back to Ice Lake. Intel's 10th-gen mobile-only processors officially launched in late 2019. After an aborted launch of the first-generation 10nm Cannon Lake CPUs in 2018 (no, we don't really count the Core i3-8121U), Intel went back to the drawing board to refine its already-two-years-delayed 10nm process. The result was a reasonably potent architecture, tied to a 10nm process that by all accounts struggled to reach the desired performance levels. Even today, with the server-focused Ice Lake SP launch having just happened, there were clearly some difficulties.

The best and brightest of the Ice Lake laptop chips reached a maximum CPU clock of 4.1GHz. That was the Core i7-1068NG7, a 28W part; the more common Core i7-1065G7 was a 15W configurable TDP chip that topped out at a less impressive 3.9GHz. Perhaps even more concerning, the mobile chips offered a maximum of four cores, with Hyper-Threading allowing eight threads. Back when Skylake was all the rage, that might have sufficed, but the attack of AMD's Ryzen CPUs made such tame configurations look far less impressive.

While Intel reworked its existing 14nm desktop offerings to eventually reach eight-core and 10-core chips, it continued to struggle with Ice Lake and 10nm. Ultimately, the decision was made to backport the CPU architecture of Ice Lake to 14nm, which comes with all sorts of difficulties. The Sunny Cove CPU cores at the heart of Ice Lake were designed and built around a 10nm node; returning to 14nm would result in much larger chips, not to mention differences in the lithography



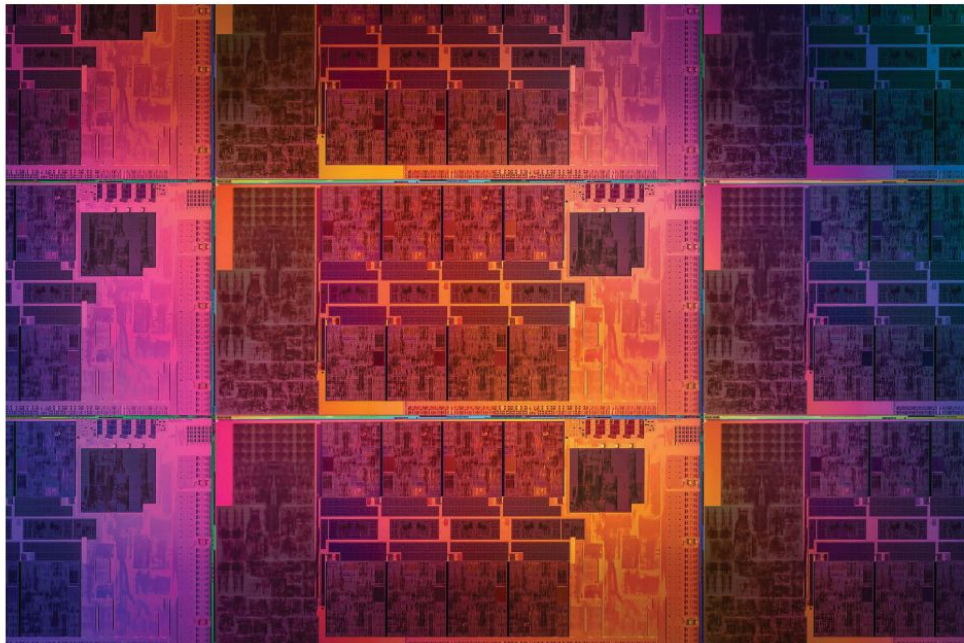
Ice Lake launched in 2019 and only offered mobile processors, but it is key to understanding the rationale behind Rocket Lake.

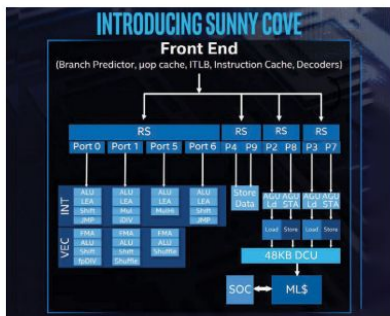
rules between 10nm and 14nm. Despite the complexity, however, Intel made the decision to proceed.

The result is the Cypress Cove CPU architecture. It takes many elements of Sunny Cove, then tunes things for 14nm, higher core counts, and higher clock speeds. Also, higher power. Outside of HEDT (high-end desktop) chips like the 18-core i9-7980XE, Rocket Lake is one of the most power-hungry chips Intel has ever created.

The CPU cores weren't the only thing that needed a swift kick in the pants. Intel's 14nm CPUs previously used Gen9 or Gen9.5 graphics solutions. Back in 2015, Gen9 might have been OK, but it can't keep up in 2021. Even the Gen11 graphics of Ice Lake were deemed

Pretty on the inside: Intel's 11th-gen Rocket Lake processors are ultimately an exercise in compromise.





The Sunny Cove architecture has lent itself to many of the features of Cypress Cove.

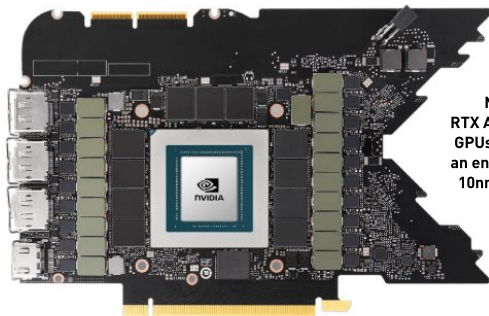
lacking, and Intel stepped up to the most recent Gen12 Xe Graphics for Rocket Lake. That meant backporting Xe Graphics from 10nm Tiger Lake (the sequel to Ice Lake) to 14nm as well. Here, however, some compromise was necessary. While Tiger Lake has up to 96 EUs in the fastest configurations, Rocket Lake is limited to just 32 EUs—it's a painful but ultimately needed compromise.

The biggest drawback of backporting both the CPU and GPU architectures to an older process is size. Intel hasn't revealed official die sizes for the resulting chip, but CPU sleuths have wasted little time in delidding and measuring the die size of Rocket Lake. The previous-generation Core i9-10900K (Comet Lake) offered 10 CPU cores and 24 GPU EUs, and measured around 206.1mm². The Core i9-9900K in 2018 was an eight-core chip that measured about 180.3mm², and the six-core i7-8700K from 2017 was just 153.6mm².

In contrast, the i9-11900K returns to an eight-core design but measures 276.4mm²—34 percent larger than the 10th-gen part, despite having two fewer cores. Even worse, compared to the eight-core 9900K, the new chip is 53 percent larger. Granted, some of that comes from having slightly more GPU oomph, but ultimately this is the price Intel had to pay in choosing to backport.

CYPRESS COVE CPU ARCHITECTURE

The good news is that backporting means Intel can finally leave behind the old Skylake CPU architecture of 2015. Rocket Lake is the first new desktop architecture



Nvidia's RTX Ampere GPUs utilize an enhanced 10nm node.

WHAT'S IN A NANOMETER?

What originally started out as a rough scale of transistor density and process technology capabilities has morphed into a marketing term as much as anything. Intel has [rightly] noted in the past that its 14nm technology was "better" than many of the competing solutions. TSMC also ended up on the wrong side of the fence with its 16nm node, which it later renamed to 12nm just to look better (with some minor refinements).

Looking forward, there are numerous manufacturing nodes coming from a variety of companies. Intel has SuperFIN and Enhanced SuperFIN 10nm nodes that are supposed to compete with the 7nm nodes from Samsung and TSMC. The problem is determining which 7nm node we're actually talking about.

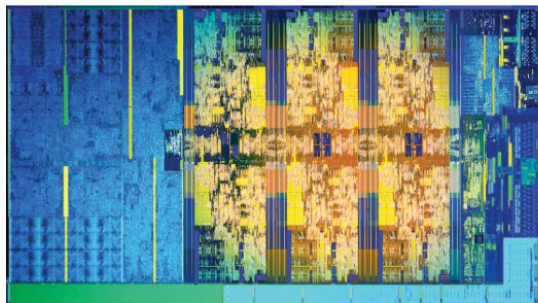
Samsung's 10nm node lands between Intel's 14nm and 10nm nodes. It's also shipping 7LPP and second-generation 7LPP, while a special 8N (enhanced 10nm) is currently in use for Nvidia's RTX Ampere GPUs. 5nm 5LPE already went through the risk production back in 2018, and retail products should presumably arrive soonish.

TSMC has the most going on, with N7FF, N7P, N7FF+, N6, and N5 nodes all in production. The various nodes are optimized for power or performance, and N7FF+, N6, and N5 all support EUV (Extreme Ultraviolet) layers. Apple's M1 and A14 chips use TSMC's N5 node.

Within any company, lower node numbers are pretty much universally better, but trying to compare TSMC N7 to Intel Enhanced SuperFIN ends up being far more nuanced. Ultimately, it comes down to density, clock speed, and power characteristics, not to mention yields—as Intel learned, a 10nm node with terrible yields isn't very useful (RIP Cannon Lake).



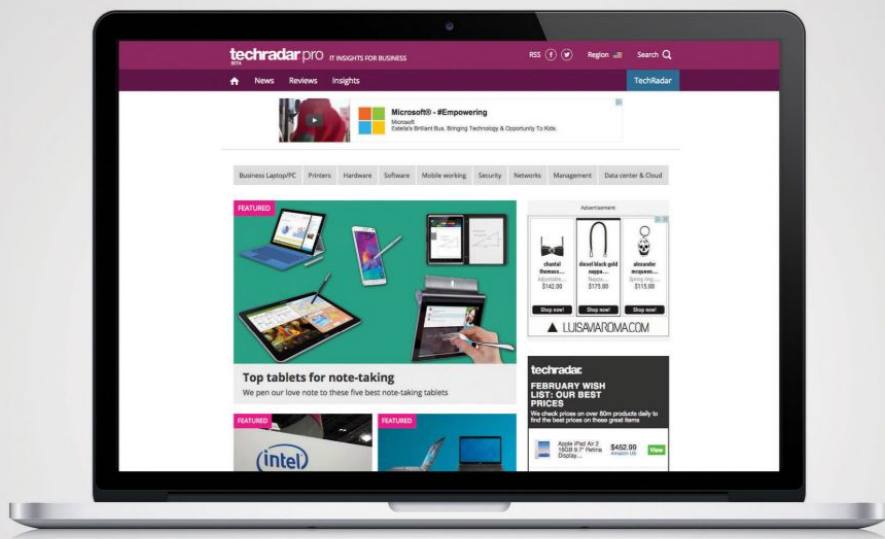
Intel's Core i9-9900K from 2018 was considerably smaller than today's 11th-gen i9-11900K.



If you can't get the yields, it doesn't matter that you have a 10nm node.

techradar.pro

IT INSIGHTS FOR BUSINESS



Best practices
and solutions



Up-to-the
minute news



In-depth
reviews

<http://www.techradar.com/pro>

from Intel since two years before AMD revealed Ryzen—which feels like an eternity ago. Intel claims Rocket Lake delivers up to 19 percent higher IPC (instructions per cycle) than Skylake, though individual gains will vary. Here's a rundown of the updates Intel made with Sunny Cove, which is largely the same as Cypress Cove.

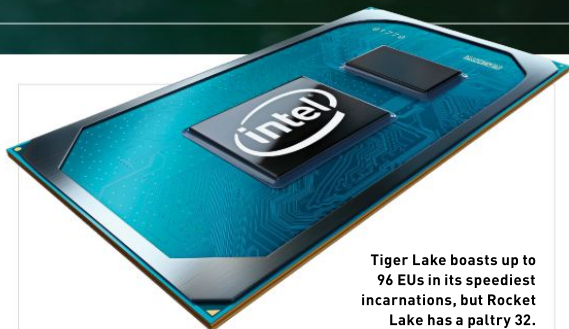
First, Intel increased the size of the caches, as well as their efficiency. The L1 data cache went from 32KiB to 42KiB, and increased set associativity from eight-way to 12-way. Set associativity improves the efficiency and hit rates of a cache by allowing it to better handle memory addresses that would otherwise overlap. The L2 cache changed from four-way to eight-way, and can be larger, depending on the product. Most Skylake desktop derivatives used a 256KiB L2 size, though Skylake-X derivatives (HEDT) had a 1MB (and 16-way set associative) cache size per core. Rocket Lake strikes for a middle ground with a 512KiB L2 cache size.

Along with the caches, various buffers and other elements are larger, too. The micro-op cache handles 2.25K entries, 50 percent more than the old 1.5K UOP cache. The L2 translation lookaside buffer (TLB) also increased from 1,536 to 2,048 entries. The out-of-order execution window size went from Skylake's 224 to 352 with Ice Lake, in-flight loads improved from 72 to 128 entries, and in-flight stores grew from 56 to 72 entries.

The front end was also made wider, going from four to five instruction allocations, and from eight to 10 execution ports. The L1 cache got twice the store bandwidth, there are four AGUs (address generation units) compared to three on Skylake, and twice as many store operations are available per cycle. To help all areas of performance, Intel also made unspecified improvements to the branch prediction.

Finally, Sunny Cove and Cypress Cove added some new instructions. These include AVX-512, DL Boost for AI Inference, and double the peak throughput for AES-NI (cryptography) instructions. It also supports a larger virtual address space for memory (57 bits, up from 48).

Mix all these improvements together, and you get the 19 percent IPC improvement. The platform also has some new features, such as PCIe Gen4 support for the primary graphics slot and first M.2 slot. Official



Tiger Lake boasts up to 96 EUs in its speediest incarnations, but Rocket Lake has a paltry 32.

memory speed support now extends to DDR4-3200 (though we've been able to reach such speeds as far back as Skylake). And topping things off, the width of the interface between the CPU and PCH (platform controller hub, aka chipset) has been doubled, with an eight-lane DMI 3.0 link in place of a four-lane link.

XE GRAPHICS GPU ARCHITECTURE

Intel hasn't been quite as forthcoming with changes to the graphics architecture, and in fact Xe Graphics, aka Gen12 Graphics, appears to largely build off the existing Gen11 Ice Lake GPU. That's still a big step forward from the old Gen9.5 desktop graphics, however.

The most noticeable upgrade in the GPU department is the move from 24 EUs (Execution Units) to 32, a minimum of 33 percent more computational power, but the underlying EUs feature some improvements that should boost performance more. Clock speeds are also higher, by about 100MHz, but that won't matter much.

The problem is that, even if the new UHD Graphics 750 doubles the performance of UHD Graphics 630, it won't be sufficient for most games. GPUs like the GTX 1050, which we consider borderline for gaming, are still several times faster than UHD 630, which presumably means at least double the speed of UHD 750.

Thankfully, Intel knows this, and it knows desktop users don't really care about integrated graphics performance—that's a way for OEMs and system builders to cheap out on the GPU and keep prices



Measuring a relatively dainty 206.1mm², the Comet Lake Core i9-10900K squeezed in 10 CPU cores alongside 24 GPU EUs.



Meanwhile, the i9-11900K has gone back to just eight cores, but still manages to take up 276.4mm² of space.



Rocket Lake is a power-hungry animal, but not as bad as the 18-core HEDT i9-7980XE.

Despite Rocket Lake's multiple updates, it still can't best AMD's Zen 3 architecture in most benchmarks.



lower. Rather than trying to compete with dedicated GPUs it can't hope to match, Intel has focused on other capabilities: The graphics engine includes HEVC, VP9, and SCC encoders that support up to 4K60 HDR, and hardware-accelerated AV1 decode support for 4K60.

While the graphics updates won't necessarily set the gaming world aflame, they should at least prove capable for media-streaming duties.

CAN YOU FEEL THE POWER?

With the backporting of architectural updates, there's another issue: power consumption. Intel used to be far ahead of AMD in the realm of CPU power requirements, but it's been on a downhill slope with desktop CPUs since 2017. The Core i7-8700K and previous two generations of Core i7s all had a maximum TDP of 95W. Overclocking could exceed that, but even at 5.0GHz the i7-8700K tended to land below 150W. That changed with the 9900K, things got worse with the 10900K, and the situation definitely hasn't improved with the 11900K.

Nominally, the 11900K has an official TDP of 125W, with a PL2 (Power Level 2) rating of 250W. That means that if the motherboard follows the exact limits, the CPU should be able to use up to 250W for a period of time defined as Tau—56 seconds, in this case. In practice, though, a lot of enthusiast (Z490/Z590) motherboards thumb their noses at such limits and will run at PL2 indefinitely—or at least until the cooler fails to keep up.

Certain workloads can even go beyond official PL2 levels, especially applications that make heavy use of AVX-512 instructions. We saw peak power, running "stock," of up to 300W during stress testing. Despite

the larger die size and greater surface area for cooling, that also resulted in temperatures peaking at 100 C. Thankfully, that's more of a worst-case scenario (Prime95), and it's the price of backporting to 14nm and then running at 4.8GHz on eight Cypress Cove cores.

Also of note is that Intel has further refined its opportunistic boost algorithms. Rocket Lake includes Turbo Boost 2.0, which allows for frequencies of up to 5.1GHz. Turbo Boost Max 3.0 adds an additional 100MHz on the fastest two cores, up to 5.2GHz. Thermal Velocity Boost allows a single favored core to reach up to 5.3GHz, or all-core clocks of up to 4.8GHz, provided the CPU temperature remains below a threshold of 70 C.

Finally, Adaptive Boost Technology (ABT) feels quite similar to AMD's Precision Boost Overdrive. It's dynamic overclocking of sorts, but it doesn't void your CPU warranty. Unfortunately, ABT is only available on the top Rocket Lake chips—11900/K/KF. ABT can kick in as long as the CPU stays below 100 C and works in conjunction with the other boost technologies. It's often disabled by default in the motherboard BIOS, but there's no good reason to leave it off as it's "free" performance.

FAILURE TO LAUNCH

Taken together, all the updates to Rocket Lake sound great, if it weren't for that pesky 14nm+++ process. The net result ends up being less than impressive. AMD's Zen 3 architecture leads in most benchmarks, and the real saving grace for Intel is that, considering the chip shortages, it has inventory relatively available. Oh, and the generational pricing is \$50 higher than Comet Lake.

There's one redeeming feature in the fact that the Core i7-11700K sports the same eight-core/16-thread configuration as the 11900K, just with slightly lower clocks—and without ABT. But manual overclocking can make up the difference if you want to take that route.

We mentioned that Rocket Lake feels a lot like the Broadwell launch, though, and that's because Alder Lake should release later this year. That's right: We'll get two new desktop CPU architectures this year. But let's douse your enthusiasm by noting that Alder Lake will shift to a new socket, LGA1700—no upgrades for existing Comet Lake or Rocket Lake users.

INTRODUCING ALDER LAKE

Intel hasn't been quite as forthcoming with architectural details on its Alder Lake processors, but we do know it plans for a complete suite of desktop chips. Alder Lake represents Intel's first fully featured hybrid x86 processor—well, second if you want to count Lakefield, but this one will be much better.

Hybrid CPU designs aren't new. ARM has been doing big.Little for a decade now, and it's pretty much standard fare for modern smartphone processors. Intel isn't ARM, of course, and x86 cores tend to be quite a bit more complex than even the larger, higher performance ARM cores. Which is perhaps partly why Intel dubs its take on hybrid CPUs "Big-Bigger."

Lakefield used a single large core (Sunny Cove, the same as in Ice Lake) with four smaller low-power Tremont cores. The catch with Big-Bigger is that all the CPU cores must support the same instruction set. Alder Lake takes what started with Lakefield and catapults it into the latest tech. The high-performance CPU cores use the new Golden Cove architecture, while the

The Core i7-8700K and previous two generations of Core i7s had a maximum TDP of just 95W—Rocket Lake has a much more voracious appetite.



smaller cores use the Gracemont architecture. The fastest configuration will support up to eight of each type of core, but that's just the start. Golden Cove is the all-in-one successor to Sunny Cove, Willow Cove, and Cypress Cove. It supports Hyper-Threading, so just on the "bigger" cores that should match Rocket Lake with an eight-core/16-thread configuration. The Gracemont cores don't support SMT, but should provide for excellent power savings, giving a final maximum configuration of 16 cores and 24 threads.

There will also be many lower spec variations, with different numbers of big and small cores. That will create some interesting possibilities, and scheduling within the OS and hardware is going to be a critical factor for performance. That's likely why Intel started with Lakefield, to pave the way for future designs. The lowest configuration is rumored to feature just two big cores (two-core/four-thread), and there will also be a four-core/eight-thread configuration with just four big cores. Models with six or eight big cores will come with zero, two, four, six, or eight little cores.

The hybrid design isn't the only big change with Alder Lake. The more important update is that it will use an updated version of Intel's 10nm process, which it calls Enhanced SuperFIN. That should dramatically improve on the chip size and power characteristics relative to Rocket Lake. There's no word yet on clock speeds or IPC, but with Intel currently trailing AMD, we expect it will try to pull out all the stops.

Alder Lake will take other technologies a step beyond AMD, by being the first consumer CPU to support both PCIe Gen5 and DDR5 memory, or at least that's the current rumor. Those might matter more on servers and workstations, and may not be enabled on all CPUs or motherboards, but we'll have to wait to find out more.

As mentioned earlier, Alder Lake, or 12th-gen Intel Core, will use a new LGA1700 socket. The new socket is required for both the PCIe Gen5 and DDR5 support, and it could include additional lanes from the CPU to other components as well. One thing that isn't changing relative to Rocket Lake: the GPU. Alder Lake will use the same Xe Graphics with up to 32 EUs on the desktop chips. The mobile variants will come

MANY MORE LAKES

Intel is never just looking one generation ahead. Here's a quick rundown of all the other lakes you're likely to see in the next couple of years.

Tiger Lake-H

The four-core models launched in 2020, but eight-core TGL-H should arrive very soon, perhaps by the time you read this. Why didn't Intel just skip Rocket Lake and give us Tiger Lake on the desktop? We're not sure, but we look forward to testing the high-end mobile solution soon.

Raptor Lake

This will be the follow-up to Alder Lake, refining and optimizing the architecture. Due in late 2022, the feature set and socket should be similar to ADL, so it will continue to run in LGA1700 boards.

Meteor Lake

This will be Intel's first 7nm CPU offering, except there's even more to it than that. Intel will outsource the production of some Meteor Lake CPUs to TSMC. It will also use

Forveros 3D die-on-die stacking, which may partly explain the outsourcing. Intel plans to also manufacture some of these CPUs in-house using its "we've fixed the problems" 7nm process. The socket for Meteor Lake has not yet been revealed, though it will likely end up similar to LGA1700 (maybe with a few pin differences to break compatibility, similar to LGA115x), and we expect this will continue the hybrid design approach.

Lunar Lake

Right now, all we have is a code name that accidentally slipped into some patch notes for Linux. Much as Raptor is to Alder, the assumption is Lunar Lake will be the optimized version of Meteor Lake, perhaps with more chip stacking and other enhancements. Could we see some parts made with TSMC 5nm? Never say never!

in a higher performance GT2 configuration with up to 96 EUs, similar to 11th-gen Tiger Lake processors.

Alder Lake should reunite Intel's desktop and mobile platforms with a single architecture. We're expecting desktop, mobile, low-power, and even Atom-type ultra-low-power designs. Server models are unlikely any time soon considering Ice Lake LP just launched.

LOOKING FORWARD

After years of delays, Intel finally has an updated desktop architecture and new chips rolling out, and it's moving beyond 14nm. All indications are that Intel's SuperFIN already matches up well with TSMC's N7 7nm node, so Enhanced SuperFIN ought to be at least reasonably competitive with upcoming N6 and N5 processes. Intel has far more going on than just Rocket Lake and Alder Lake, of course (see "Many More Lakes").

Alder Lake isn't expected until the end of this year, though we suspect Intel will want Alder Lake sooner rather than later. There's no word on TDP or clock speed yet, but we expect it to be far more competitive than what Intel currently offers. If you're already running an eight-core CPU like the i7-9700K or better, or a Ryzen 7 or higher AMD chip, skipping the Rocket and waiting for Alder Lake looks like a reasonable option.

The next Intel versus AMD showdown looks set for later this year or early 2022. By then, Team Red might have Zen 4 CPUs for us, also with PCIe Gen5 and DDR5 support. Rocket Lake didn't quite hit the mark, but Alder Lake is promising, with future 7nm options closing the gap. The next year should be far more exciting in the CPU realm than late 2020 and early 2021, at least. ☺



DISCOVER THE UNIVERSE

www.spaceanswers.com



NEW ISSUE ON SALE NOW!

EXPLORATION



SOLAR SYSTEM



DEEP SPACE



FUTURE TECH



ASTRONOMY



Print and digital subscriptions available at
www.magazinesdirect.com



/AllAboutSpaceMagazine



@spaceanswers



space@spaceanswers.com

SUBSCRIBE TO **MAXIMUM PC**

GREAT REASONS TO SUBSCRIBE

- Save over 74% when you subscribe.
- Never miss an issue.
- Get every issue delivered direct to your door.



**FREE
BOOKAZINE**
WHEN YOU BECOME A
**MAXIMUM PC
SUBSCRIBER**



TO ORDER GO TO
www.magazinesdirect.com/mpc/B1GMAG

TERMS AND CONDITIONS Offer open to new US subscribers only. Pricing is guaranteed for the first 12 months and we will notify you in advance of any price changes. Please allow up to six weeks for delivery of your first subscription issue (up to eight weeks overseas). The full subscription rate is for 12 months (13 issues) and includes postage and packaging. If the magazine ordered changes frequency per annum, we will honor the number of issues paid for, not the term of the subscription.
For full terms and conditions, visit www.magazinesdirect.com/terms. Offer closes: July 20, 2021.

Getting Started With Raspberry

Single-board computers have captured the imagination of many PC builders. Here's *Ian Evenden's* beginner's guide to getting a Raspberry Pi up and running



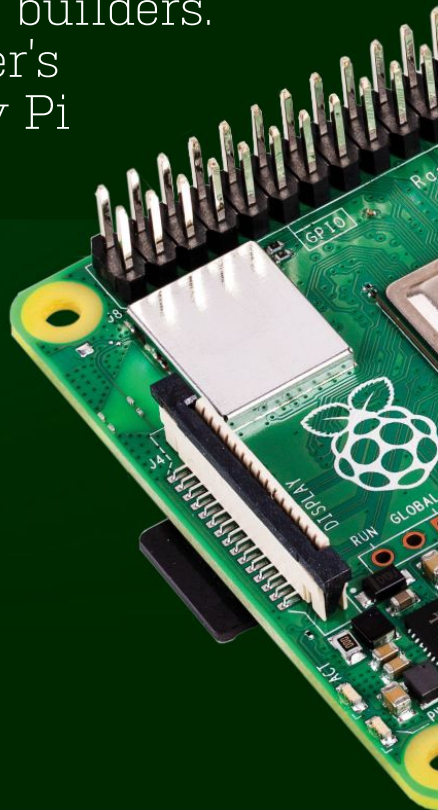
Why do we love the Raspberry Pi so much? Possibly because it's the purest form of computer hardware. Unadorned by cases or fans or RGB (unless you want them), you're forced to get your fingers in there and handle the PCB if you want to do anything.

You can put it in a case or you can run it naked, without so much as a heatsink, but fans have to be plugged to specific pins on that tempting GPIO array. Which sparks the thought—what else can they do?

It's also a highly disruptive device. Our small computers—smartphones and tablets mainly—are sleek and expensive, and come armed with expansive software libraries. The Pi is cheap—cheaper still than many other single-board computers—and is backed by a decent software library, with a distinctly educational focus, thanks to its Debian Linux-based operating system. This means you can use it as a PC for everyday tasks, as well as creating your own electronics projects, and using it to learn programming or play retro games.

If you've ever wondered why sections of the computing community are going mad for this diminutive PC, here's our guide to starting out in this wonderful world.

© RASPBERRY PI FOUNDATION





Pi



A Little History

The Raspberry Pi isn't one thing. There have been several models, some smaller than others, and it sits across a couple of market sectors. When we say a Raspberry Pi, we're generally talking about the current "big" model—the 4B. This is the one you can see in its naked glory across the opening spread of this feature. It's got Ethernet, lots of USB ports, and the fastest CPU and most RAM of the lot.

The product of a UK-based charity (The Pi Foundation) that's working to get cheap computers into the hands of people all over the world, the Pi 4 has four main predecessors. Starting out in 2012, the original Pi had an ARM 11 32-bit processor, 512MB of RAM, Ethernet, HDMI, a microSD card slot, 26 (later 40) GPIO pins, headphone socket, and two USB 2.0 ports. It went through a few revisions, including a "compute module" that fits in a DDR2 SO-DIMM form factor for industrial uses. It introduced the Pi's camera and display ribbon-cable ports.

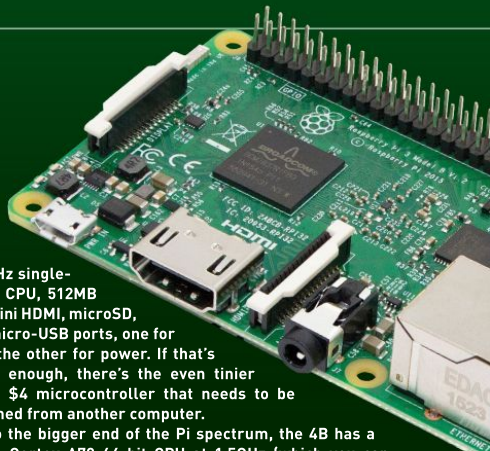
This was superseded in 2015 by the Raspberry Pi 2, which brought a 900MHz (later 1.2GHz) ARM Cortex processor and 1GB of RAM. Again, there were a few revisions, until the Pi 3B was released in 2016 with a 1.2GHz ARM Cortex A53 CPU, and onboard Wi-Fi and Bluetooth. This could boot from USB, and received an upgrade, the B+, which speeded up its networking and processor. A compute module was also available.

Alongside, there have been other releases. The Raspberry Pi Zero comes in three different varieties depending on how much you need wireless communication and GPIO pins soldered to the board. It's tiny, selling for \$7 on release in 2015, and comes

with a 1GHz single-core ARM CPU, 512MB of RAM, mini HDMI, microSD, and two micro-USB ports, one for data and the other for power. If that's not small enough, there's the even tinier Pi Pico, a \$4 microcontroller that needs to be programmed from another computer.

Back to the bigger end of the Pi spectrum, the 4B has a quad-core Cortex-A72 64-bit CPU at 1.5GHz (which you can overclock if you add active cooling). This is backed by up to 8GB of RAM, and the board features Wi-Fi 5 and Bluetooth 5, Gigabit Ethernet, two USB 3.0 ports and two USB 2.0, all the usual GPIO pins, microSD, and ribbon cable ports, and a pair of Micro HDMI ports that can drive a screen up to 4K at 60Hz. There's a compute module, and a variant model, the Raspberry Pi 400, that is installed inside a keyboard, with cooling that lets it run at 1.8GHz, but at the expense of one of the USB 2.0 ports.

So, what you've got in a Pi 4 is the guts of a smartphone from 2016 with a bit more RAM and lots more connectivity. The USB ports support a vast range of peripherals, and the GPIO pins allow for power and data connections to more homemade gear.



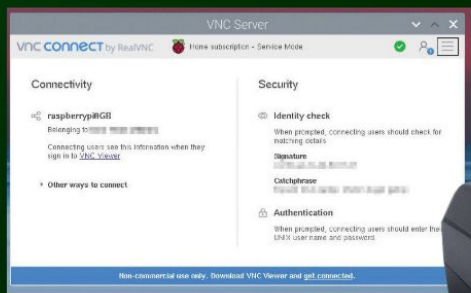
On the Case

So, if you're looking forward to learning Python, bashing together a robot that takes commands over Bluetooth, or just fancy a tiny PC you can work on with fewer distractions (they come with a web browser, so this isn't entirely possible), or use as a streaming box or media server, the easiest way in is with a model 4B or a 400.

The first thing to do is buy a kit. They're available on well-known online shopping sites or directly from the Pi Foundation itself, and generally consist of a case, a heatsink or fan, a power supply (the 4B takes its power over USB-C, and will run from a tablet or laptop charger, but the specialized power supplies have an on/off switch that's useful, as there isn't one on the board itself), a microSD card with some sort of software on it, and maybe a Micro-HDMI-to-HDMI adapter, too.

The cases available for Raspberry Pi boards are myriad. They range from those that are just a plastic shell, like the official one, to those that are all heatsink, for enhanced passive cooling. Some come with fans, others a touch of RGB, more with both. As the 400 comes with a keyboard, there's a kit available that bundles an official USB mouse, but we've never had any problems with the peripherals we hook up to a Pi's USB ports, with all keyboards and mice working perfectly.

As the 4B can boot from USB, you might want to consider an SSD for a speed boost over microSD, and maybe a case made to hold one, such as the Argon ONE M2, which accepts SATA M2 SSDs, adds active and passive cooling, and fixes the Pi's



Set up a VNC server to operate your Pi on your PC or phone.

esoteric port arrangement, moving them all to the back of the case and turning the Micro HDMI's into full-size models.

It even adds an IR remote sensor, for all your media center needs. The downside is that it costs more than the Pi board itself does, but for an all-in-one solution, it's hard to beat.

Alternately, you can buy everything separately. The Pi is available as a bare board, and will boot if you feed it a compatible OS, 5V over the USB-C, and have some way of viewing its video output. You need a mouse and keyboard to navigate the initial setup screens, but after that you can set up a VNC (Virtual Network Computing) server and disconnect it from everything except power and the boot drive, operating it through the VNC Viewer app on another PC, phone, or tablet.

Alternate Boards



Left: The Raspberry Pi 3B was the first to boot from USB.



Right: The Zero model cost just \$7 when it first appeared.



Left: Nvidia's Jetson AGX Xavier kit is a great way to get into robotics.

Below left: Cases such as the Argon ONE M2 add cooling to your Pi setup.

Below centre: Need more processing power? Try AAEON's UP Xtreme i11.

Below right: The Rock Pi X trumps the Raspberry Pi by having a power switch.



The Raspberry Pi isn't the only single-board computer out there. The sector is a booming one, and they're not even all based on ARM processors.

The Rock Pi X has a quad-core Atom processor that turbos to 1.8GHz, and Intel HD Gen 8 graphics. It looks remarkably like a Raspberry Pi, although there are differences in the USB and HDMI ports. It can run Windows 10 or Ubuntu, comes with built-in Wi-Fi and Bluetooth, and has a 40-pin GPIO header. There's up to 4GB of RAM and 128GB of eMMC flash on board, along with a microSD port, and it has its own power switch—an improvement over the Raspberry Pi. It's a little more expensive than the Raspberry Pi, and you have to factor in the cost of Windows, too, if that's what you want to run.

For a bit more processing power look at the UP Xtreme i11 from AAEON, an associate company of Asus. You can fit it with a quad-core i7 if you need to, and up to 64GB of RAM. It's got lots of connectivity, including two Ethernet ports (one 2.5Gb), but pulls 32W of power, so no powering this with a tablet charger. You can fit an M2 SSD to the bottom of the board for speedy storage, and you get both DisplayPort and HDMI video-out. The boards will be available in the second quarter of this year, so we don't have a price yet, but others in the series have sold for around \$600.

And if you want to develop software for AI, machine vision, self-driving cars, or robotics, you could do worse than the Nvidia Jetson AGX Xavier development kit. It's the most powerful in its range, with an eight-core ARM processor, 32GB of RAM, the same amount of eMMC flash, and a 512-core GPU based on the Volta architecture. They were once available on Amazon for \$700, but at the time of writing had gone off sale.

Setting Up

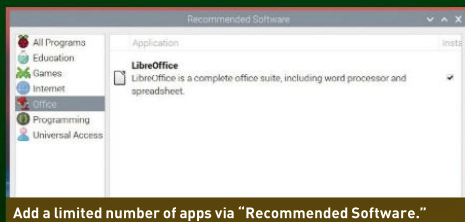
If you buy a kit, there's a good chance the microSD card that comes with it will contain NOOBS—that's New Out Of Box Software, by the way, not an insult from *Counter-Strike*. Pop the card into the Pi and switch it on—the software talks you through the process of installing an OS, most likely the official Raspberry Pi OS if you're just starting out. Alternately, if you've got a PC handy, you can use the Raspberry Pi Imager app (www.raspberrypi.org/software) to download and install one manually.

You can use any size of microSD (we've never found the need to go particularly large; 32GB cards are common), but it must be formatted as FAT32, which the Imager can do for you, as Windows 10 probably won't. OS images are downloaded from within the app, and there are several available. Alternatives to the official OS tend to be aimed at specific uses, or advanced users, but Ubuntu is available as a full 64-bit OS that can use all that lovely 8GB of RAM (if you've bought that model).

There are a few versions of the Raspberry Pi OS. There's the recommended version, which is the GUI but very few apps beyond a browser. Then there's the Lite version, which doesn't even have the GUI and is for those who know the Linux command-line interface or feel like taking a crash course. Then there's the Full version, which bundles the GUI with recommended software. Unless setting up a Pi for a specific purpose, we tend to go for the Full version—storage is cheap.

After it boots (watch the red and green LEDs flicker), the setup process goes through things like choosing your location and language, and connecting to Wi-Fi. You're asked if your display is overscanning, and the system reboots—it's an efficient and quick process. Note that while there's password security on the Pi, it's often set to automatically log you in—you can change this if you want.

Raspberry Pi OS doesn't take particularly long to boot, even from a microSD card, so you'll soon be back to the desktop, wondering what to do. The very first thing is to run some system updates, for which you need to open Terminal. Most Pi administration still takes place in the text-based world



of the Terminal window. While there is a GUI version of the Raspberry Pi Config app, for example, we find the Terminal version to be better.

To run the updates, type `sudo apt update` and let it do its thing. Once it's finished, and you're returned to the Terminal prompt, type `sudo apt full-upgrade` and type `y` when you are prompted. There may be a fair bit of downloading involved, depending on how out of date the OS image you installed is. While we wait, let's unpack what we just typed. Your standard user account doesn't have administrator privileges, so the `sudo` part gives you the privileges to change files you don't own. It means "superuser do." Then, `apt` is the name of the Linux Advanced Packaging Tool, which handles the software installation and updating. `Update` and `upgrade` are commands for `apt`, with `full-upgrade` used here as it picks up changes in more things.

We can see `apt` in action again by installing Firefox. Open the Terminal window and type `sudo apt install firefox-esr`; Linux can install software from online stores called repositories, and the Pi pulls its software from the Raspbian Repository unless you tell it not to. So, in this line of text, we have the `sudo` privilege escalator, a call for `apt` to install something, and the name of the app we want to install—change this to GIMP or Scribus or LibreOffice to get the app you want. Firefox ESR is the Extended Support Release version of Firefox—it may miss a few of the latest features but is up to date security-wise.

There is also a Recommended Software app on the Raspberry Menu, which provides a GUI way to install a limited range of programs.

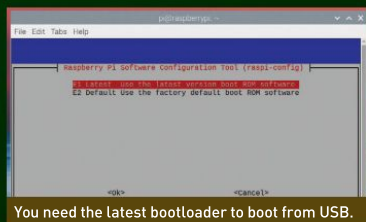
Boot From USB

Booting your Pi from USB is simple, but requires a check that you're using the latest bootloader. Booting from USB opens up the ability to run the OS and apps from a SATA SSD (you're limited by the speed of USB 3, so NVMe would be overkill) for a speedier, more responsive feel. We've tried running the Raspberry Pi OS, Ubuntu, and even

Windows 10's ARM port from a microSD card, and the performance wasn't bad, especially if you're mostly reading from the card. Once you start doing lots of writes, however, the microSD starts to show its weaknesses. Booting from an SSD fixes this, and makes everything feel faster.

Make sure your Pi is fully updated using the `sudo`

`apt full-upgrade` Terminal command, and then input `sudo raspi-config` to open the configuration tool (this option isn't on the current GUI configuration tool). Scroll to "Advanced Options," then "Bootloader Version." Press Enter, then choose "Latest." Now go back to "Advanced Options" and choose "Boot Order." Choose



the top option (boot from SD card if available, otherwise boot from USB), and press Enter. Press the right arrow to move across to "Finish" to exit the tool. Your Pi

will now boot from USB only if a microSD card isn't in the slot. This allows you to flash new OSes to microSD and try them out, without disturbing the main OS you keep on a USB SSD.



Choice of Software

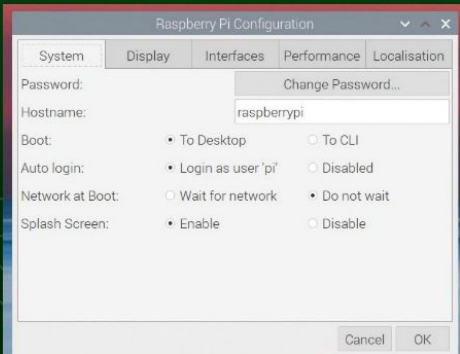
Raspberry Pi OS comes with the Chromium browser. This is the open-source fork of Google's Chrome, and it's not bad. One thing it's missing, however, is syncing. If you want to see your bookmarks and history synced between your Pi and your main PC, that's not going to happen with Chromium.

Syncing does work in Firefox, however, and in our opinion it's a nicer browser to use on the Pi, even though we're big Chrome fans on Windows. Others recommend Vivaldi (<https://vivaldi.com/blog/vivaldi-for-raspberry-pi/>), which has plenty of customization options and seems quite snappy.

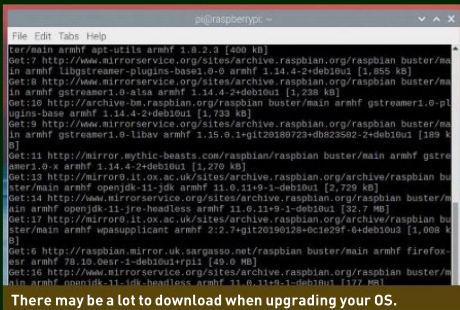
There's enough software available in apt to make a Pi 4 into a worthwhile desktop replacement—GIMP, Scribus, and Inkscape should scratch the creative itch, while the full LibreOffice suite can pick up the boring tasks.

Overclocking (get a fan, it's at your own risk) makes it an even better experience, smoothing out the jerky edges and frame rates. If you need more software, you can install the Synaptic package manager from the Terminal ("sudo apt install synaptic"), which opens up a wider range of software in a nicer GUI than Raspberry Pi OS's Recommended Software option.

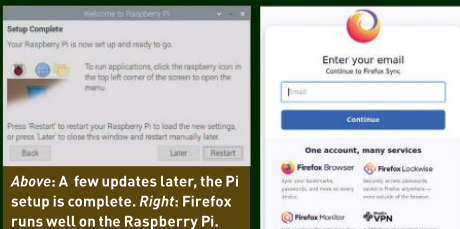
There's the Transmission BitTorrent client, Pidgin messaging app, *Minecraft*, and open-source clones of *Civilization* ("sudo apt install freeciv-client-sdl") and *SimCity* ("sudo apt install micropolis"). Then there are the programming languages and educational tools the Pi is famous for. Raspberry Pi OS comes with a few installed (with the Full version), such as Thonny, a Python development environment for beginners, and Scratch, a visual programming language targeted at 8 to 16-year-olds.



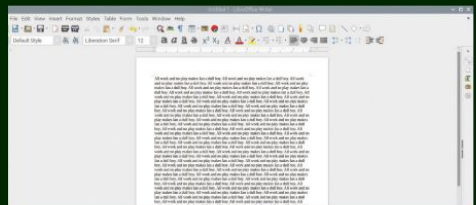
We prefer to use the Terminal version of the config app.



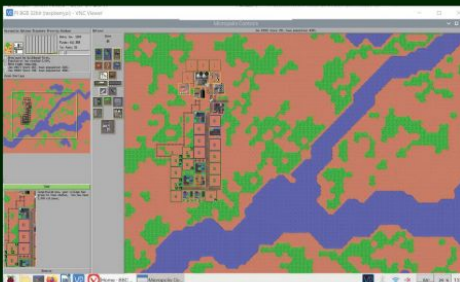
There may be a lot to download when upgrading your OS.



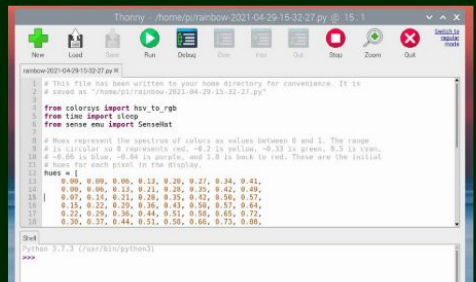
Above: A few updates later, the Pi setup is complete. Right: Firefox runs well on the Raspberry Pi.



LibreOffice should fulfill most of your productivity needs.



Micropolis is a Pi-friendly open-source clone of *SimCity*.



Set off on your Python programming path with Thonny.

Cameras and Screens

Before we get into projects and add-ons, let's explore those two ribbon cable connections on the Pi board.

One is for cameras—there are a few available, with the official board now on V2, with eight megapixels, and a decent Sony image sensor. That said, the sensor is tiny and the lens is fixed, so it's like using a cell phone camera from 2006. There's a version without the IR filter, too, for night vision applications, though you'll need

to provide your own IR light.... Perhaps with an LED and those GPIO pins? Third parties have got in on the act, too, cloning the official cameras and offering up their own compatible versions, sometimes with bonus IR lights with sensors that switch them on when light levels drop beyond a set threshold.

On top of that, there's a High-

Quality Camera. This plugs into the same ribbon connector, but gives you 12 megapixels on a much larger sensor chip, and can take interchangeable C-mount lenses. This is a bit of a game-changer for Pi photography, because once mounted on a tripod, the HQC can be used for astrophotography and wildlife camera duties, without worrying about a lack of image quality. You could also use it as a webcam, if it weren't for those USB ports.

The cameras generally come with a ribbon cable included (you'll need an adapter or special cable to use them with the Raspberry Pi Zero), though it's not very long. You can buy lengths of it up to six feet, and there's a clever third-party add-on that sends the same signals along an HDMI cable up to 30 feet. The ribbon cable ports have a small latch that needs to be lifted up before

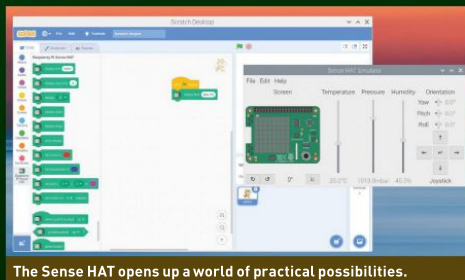


Things to Make and Do

One of the main drivers behind the development of the Pi line is as a base for electronics projects, and it excels in this area. Things such as sensors, LEDs, relays, and motor controllers can be attached using those 40 GPIO pins, and a language such as Python used to control them.

And then, literally on top of that, there are HATs. Standing for Hardware Attached on Top, HATs add additional functionality to a Pi by clipping on top of the board and connecting to the GPIO pins. Basic examples include power over Ethernet, or USB 3.2 ports. Then there are e-ink screens, electronics breadboards, LED traffic lights, air quality measurement devices, hi-fi sound output (the Pi 4 has a 3.5mm audio jack, and Bluetooth, as its native audio out), a multi-camera board, temperature sensors, heart rate detectors.... If you can think of it, then someone has probably already built something to do with it, and if they haven't, there's nothing standing in the way of you building it (as long as it can be done with basic electronics and doesn't need more processing power than the Pi can provide, of course).

Here's a good place to get started: The Sense HAT was built for a space mission—Raspberry Pis were taken to the ISS aboard a cargo rocket, and have been running experiments designed by schoolchildren. The HAT includes 64 RGB LEDs, an eight-way joystick, and six sensors: gyroscope, accelerometer, magnetometer, humidity, air pressure, and temperature. There's even an emulator for it that comes with Raspberry



The Sense HAT opens up a world of practical possibilities.

Pi OS, so you don't even need to buy a physical unit (though it does look good if you do, and that's the only way to get accurate readings from the sensors). The Sense HAT uses Python or Scratch commands to interact with its hardware. One of the simplest things you can do is make text scroll across the LED array by dragging and dropping blocks in Scratch 3, then editing the text to make it say what you want. For those of us not taught computer programming at high school, it's a revelation.

From here, the sky's the limit. You can create a robot, a weather station, a media center, a NAS array, a motion-sensing

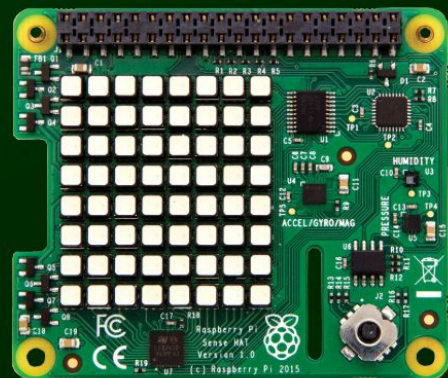


The High-Quality Camera offers an impressive 12 megapixels.

the cable is inserted, and the cables have to be put in the right way around. It's also tricky to plug and unplug them when there's a case on the Pi, especially one of the heatsink ones that fastens on tightly with hex bolts.

Anything you can plug into the Pi's USB ports will probably work, too, as long as it doesn't need exotic Windows-only drivers. That means USB drives, webcams, card readers, game controllers, mouse and keyboard dongles—they're all game.

Screens can, of course, be attached to the Micro HDMI ports—the Pi 4 has two, and they're capable of driving a pair of monitors at 4K. There's an additional ribbon cable connector dedicated to screen connection, however, which comes in handy for projects in which you turn the Pi into a sort of tablet by connecting a touchscreen.



security camera hub, a retro-gaming console, a night-vision camera to spy on the wildlife in your backyard, or anything else you can imagine. And the very best thing is that these little boards are being aimed at children, so the next generation will have a knowledge of programming and electrical engineering that far surpasses that of their parents. This is why we're so enthusiastic about the Raspberry Pi: It's a pure form of computing—we like the way that all of its chips and ports are out on display—and it's spreading the love for making stuff far and wide. ☺

Alternate OSes

There are several choices for the OS you run on your Pi, mainly different flavors of Linux but with some occasional surprises. Last issue, we showed you how to run the ARM port of Windows 10, but even the Pi 4 is a little underpowered for that right now—this may change if an official port emerges.



Many of these are available on the Raspberry Pi imager, or as an ISO file online you can download and feed into the Imager app. For now, the best choice for most people is the 32-bit Raspberry Pi OS; it's built on solid Linux foundations, and contains enough apps and learning tools for anyone to use the Pi happily for ages.

The 64-bit port of the OS is in development, and you can download it from the Raspberry Pi forum. It's come a long way in the last few months, but there are still things that don't work—like the VLC media player—and it has some quirks, especially when trying to run it over VNC. It is a little faster than the 32-bit OS, and is one of the only ways of using all the RAM on an 8GB Pi, so it can be worth checking out.



Ubuntu is the big desktop Linux OS that everyone's heard of, and its 64-bit Pi port runs quite nicely, especially if you can overclock. It's probably only worth checking out if you're already used to the way Ubuntu does things, however, and you want to use your Pi as a desktop replacement, because most of the software it runs is available on Raspberry Pi OS anyway. It's available from the Raspberry Pi Imager, though, so there's nothing stopping anyone with a spare microSD card from trying it out.



RISC OS is an open-source OS designed for ARM processors written by the people who made the original ARM chip. It's neither Linux nor Windows, so is a bit different from everything else out there, and so again is probably not for beginners or anyone who just wants to play with the Pi's programming features.



RetroPie is heaven for retrogamers—it combines a lightweight Linux OS with a controller-friendly front end and enough emulators to keep you playing for months. Where you get your game ROMs from is your business. We'll have no talk of that here. Recalbox does something similar, so see which one appeals to you the most.



Finally, LibreELEC is a Kodi Entertainment Center distribution that (along with its close relative OpenELEC and OSMC) can transform your Raspberry Pi into a media server capable of feeding your television with whatever media files you happen to have lying around your home network.



PC GAMING: A HISTORY

PC gaming has come a long way. *Christian Guyton* looks at where it's been and where it might go next

IT'S FAIR TO SAY that when Connecticut-born physicist William Higinbotham started messing about with the trajectory-plotting features of the Donner Model 30 analog computer—a chunky block of metal covered in dials, designed for calculating the flight paths of ballistic missiles—he probably didn't think he was birthing a medium that would eventually come to rival the film and music industries in terms of scale and worth. And yet, in 1958, at Brookhaven National Laboratory on Long Island, New York, that's exactly what he did.

His initial prototype took only a few hours to design and less than a month to implement, using an oscilloscope display to render a simple “ball” and lines, along with a pair of custom-made controllers, each with a single button and dial. Two players took turns hitting the animated dot back and forth, using the dial to control the angle of each return shot.

Higinbotham—formerly a member of the team that developed the first atomic bomb, later a staunch advocate of nuclear nonproliferation—said that he thought his little game would “liven up the place,” and he was absolutely right. At Brookhaven's annual public exhibition, hundreds of tech enthusiasts and high-schoolers lined up to play *Tennis for Two*. The display was so successful that an improved version was put on show the following year, allowing players to simulate playing tennis in the low-gravity environments of the Moon and Jupiter. The machine was dismantled following

the 1959 exhibition, its components required for less esoteric purposes.

Fortunately, that wasn't the end of it. More than 60 years on, high-schoolers still like pushing buttons to win at virtual sports, but the systems that power those digital matches have evolved beyond anything Higinbotham could have imagined. Last year, *AO Tennis 2* was released, showcasing a fully modernized and breathtakingly detailed tennis experience, right down to the yellow fuzz on the ball and the sweat on Nadal's brow.

The games and computer hardware industries have come a long way in those 60 years, slowly making their way from government-funded labs into our homes and pockets. So, just as Higinbotham charted the trajectory of his tiny “tennis ball,” we're going to chart the momentous rise of the PC gaming industry.



Tennis for Two on an oscilloscope and played with two custom aluminum controllers.

© BIG ANT STUDIOS; IMACON; BIGBEN INTERACTIVE; WIKIMEDIA

TENNIS FOR TWO wasn't exactly the first PC game to be created. For starters, the concept of a personal computer was alien at the time; multipurpose computers with real processing power were huge, while semiconductor technology was still in its infancy. Eight years before Higinbotham created his tiny tennis simulation, Canadian scientists produced Bertie the Brain, a 13-foot-tall behemoth capable of playing tic-tac-toe against a human opponent with varying levels of difficulty. Although Bertie was largely written off as a fun novelty at the time, adjustable difficulty levels remain relevant in games today, more than 70 years later.

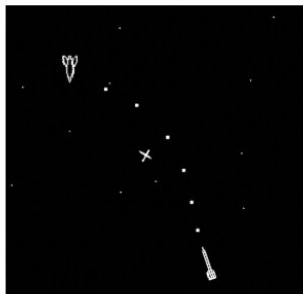
There is some dispute as to what the first "PC game" is. Bertie was considered a "game playing machine," but it lacked a proper display, simply using light bulbs and shaped cutouts of Xs and Os. Is this arguably a 3x3 resolution screen? That's not for us to say. *Tennis for Two* cleverly utilized an oscilloscope as its display, but some argue that the first "true" PC game was *Spacewar!*, another two-player game designed by computer scientists at MIT for the DEC PDP-1 minicomputer in 1961.

If *Tennis for Two* was the precursor to *Pong*, *Spacewar!* was undoubtedly the inspiration for *Asteroids*. Players controlled two spaceships facing off against each other in the gravity well surrounding a star, everything presented in tiny dots, lines, and polygons on the PDP-1's early CRT display. With limited fuel and missiles, the goal was to destroy your opponent's ship, either with your own weapons or clever maneuvering to force a crash. While the first version was controlled with the PDP-1's mess of tiny switches, programmer Bob Saunders created the first gamepads ever to exist, to better facilitate two-player games.

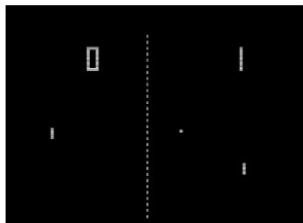
Spacewar! enjoyed cult popularity among the computing community in the '60s, helped by the fact that its code was placed in the public domain. Other PDP-1 owners were able to play the game, and it was also ported to later models of the PDP. Some programmers using different computer systems even recreated their own versions. *Spacewar!* was even modified into *Computer Space*, the world's first arcade game unit, ultimately spawning coin-op arcade gaming.

HOME BREWED

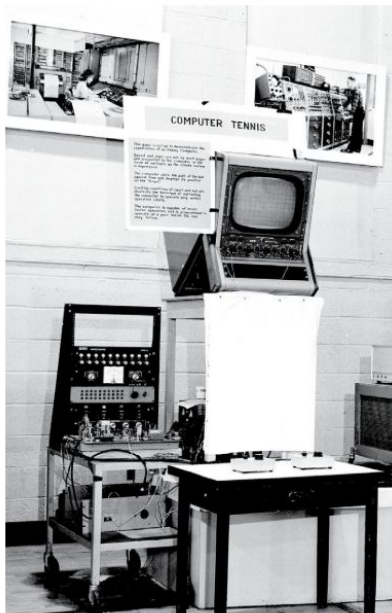
As advancements in microprocessor tech saw CPUs become more efficient, more powerful, and less expensive, the '70s saw the rise of microcomputers. These were easier to store and use than previous models, creating a template for the home desktop PCs we see today. The lower price



Spacewar! looks seriously basic now, but it was a huge step in game graphics.



Starting life as an arcade machine game, *Pong* was ported to many early computers.



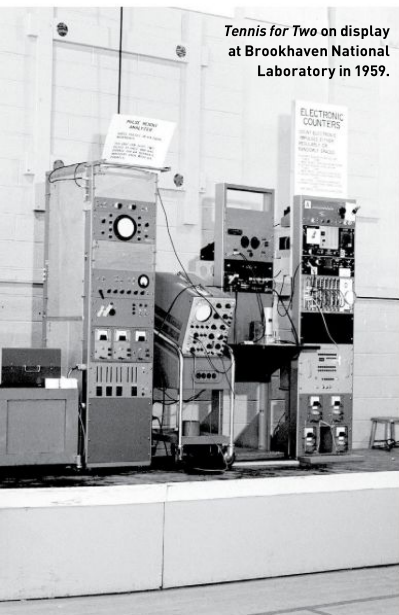
The Bard's Tale tapped into the overlap between computer geeks and tabletop role-players.

of admission also meant that computing was further opened up for hobbyists, with software and hardware enthusiasts alike able to experiment and create in their own homes.

We arrived at what could be called the first proper generation of games. One-man unpaid development teams and limited graphical power meant that these early games, produced and distributed throughout the hobbyist community, were

primarily simple text-based adventures. Interactive fiction came to computers, taking cues from the cult success of choose-your-own-adventure books. Years later, the genre persists in the form of visual novels (and, yes, dating sims).

At this point, the publication industry saw a chance to capitalize on the burgeoning popularity of PC games. *Creative Computing* was one of the first such publications, established in 1974. The



Tennis for Two on display at Brookhaven National Laboratory in 1959.

magazine came with cassettes containing code for various games and programs, enabling readers to experience a broader variety of games. *Creative Computing* didn't make it into the 21st century, but the trend persisted, leading to modern-day giants such as *PC Gamer* and, of course, the magazine you're reading right now.

By the time the '80s arrived, the first consoles were being sold commercially, with personal microcomputers advancing to a point where real graphical fidelity was starting to become an option. Suddenly, those text-based adventure titles needed to offer more; a backbone of narrative options and role-playing stat sheets was fine, but players wanted to see their characters actually move through these fantasy worlds.

The Bard's Tale—no relation to the 2004 comedy game of the same name—was one of these such games, leveraging detailed pixel art of dragons and goblins to support bulks of text and hidden dice-rolls. Dungeon-crawlers of this ilk were popular, no doubt due to the correlation between computer enthusiasts and tabletop gamers at the time. Most other games that achieved commercial success were ports of already-popular arcade titles, such as *Frogger* and *Pac-Man*. Simple but effective graphics prevailed in these games; *Pac-Man*'s ghosts were tiny,

CONSOLE-ATION PRIZE

The console gaming industry has expanded for years alongside PC gaming. We're all familiar with titans such as Nintendo and Sony, but no matter what number comes after the new PlayStation, we're actually currently in the ninth generation of home consoles.

The first console to officially hit the market was the Magnavox Odyssey, which loaded games from "cards," which were essentially PCB cutouts, years before cartridges or disks would become the norm. The Odyssey was only capable of displaying a monochrome line and three dots, and had a total of 28 games, 12 of which were bundled with the system.

Many early home consoles were effectively limited microcomputers using dedicated controllers, rather than keyboards. The Atari 2600 ran with a simple joystick, while the ill-fated Fairchild Channel F used a strange clickable analog stick at the end of a grip. It wasn't until the third console generation that conventional gamepads began to make an impact, with the NES and Sega's Master System popularizing the new control method.

Things haven't changed all that much since. The Xbox

Series X and PS5 are just gaming PCs in fancy cases running custom operating systems on specially designed APUs. Console game quality leaps forward every few years as the industry stumbles into each new product generation, as opposed to the steady component-based drip-feed of improvements seen on PC.

One area where PC has yet to properly catch up is handheld consoles (although you should check out Alienware's Concept UFO). The growing use of LCD displays in the '80s saw the creation of Nintendo's Game & Watch devices, with the notion finally being brought to fruition in 1989, with the Game Boy. This spawned a series of successful Nintendo handhelds, with fierce competition from Sony for a while with the PSP and PS Vita product lines.

Will handheld PCs one day become the norm? Our phones have certainly become more and more like traditional computers, though we'd like to forget the awkward outing that was the Windows Phone. 5G rollouts mean streaming to a phone or tablet from your desktop PC

is a real option, but will we be assembling custom pocket-sized gaming rigs a decade from now? We'd like to see it.



The Magnavox Odyssey certainly doesn't look like the sleek home consoles of today.

low-resolution sprites with only three colors, but they remain iconic even today.

With serious (well, serious for the 1980s) PCs hitting the market, gamers were spoilt for choice: ZX Spectrum, Commodore 64, Amstrad CPC, and more. Even the Apple II saw a decent share of early game development, long before Steve Jobs decreed that Apple computers aren't PCs and triggered a decades-long divide between Windows and Mac users.

The entry price for home computers at the time was fairly steep, but comparable to a modern high-end PC; most sat between \$2,000 and \$4,000 in today's money. Budget options weren't really available yet, but for those with the cash,

there was plenty of choice. Although the World Wide Web was yet to bring about forums and online multiplayer, magazines, exhibitions, and hobbyist clubs kept the ball rolling. Consoles were here to stay, too, providing a less adaptable but more affordable alternative for those interested in home gaming.

Prior to the 1980s, third-party game developers didn't really exist; most games were produced by the hardware manufacturer's parent company or created unofficially by amateur coders. It wasn't until the creation of Activision in late 1979 that third-party game studios were born, as a group of programmers broke away from Atari to design their

VIRTUAL WORLDS

Proponents of VR like to claim that it is here to revolutionize gaming, but the technology has actually been kicking around since the '70s, initially used for military and flight training purposes.

The first VR headsets designed for gaming emerged in the early '90s, when Sega announced a headset for its Mega Drive console. Unfortunately, Sega VR never made it into consumers' homes, with only a half-baked arcade version ever seeing the light of day. A handful of other manufacturers attempted to develop similar technologies, but the gaming public remained indifferent until 2012, when engineer Palmer Luckey and id Software co-founder John Carmack revealed the first Oculus Rift headset at the E3 expo.

The Rift was a revelation for the VR industry. Improved tracking, a wider field of view, and better eye displays meant that it was a serious piece of hardware, prompting a huge resurgence in public interest in VR. The cat was out of the bag. By 2016, more than 200 companies were developing VR-related products. Major competitors, such as HTC's Vive and Sony's PSVR, hit the market. Samsung and Google released headsets that used the player's smartphone as a display and motion sensor, although these struggled in performance compared to "tethered" headsets that connected to a PC.

The release of the Oculus Go (and later the Quest) brought the option of untethered VR, using an onboard Qualcomm chip to render graphics without a PC. The success of 2019's Valve Index says that gamers aren't done with VR headsets that hook up to powerful gaming PCs, but the popularity of the Quest series suggests that as portable gaming tech improves, VR might shift away from PCs and become more like a self-contained console industry.



The humble VGA connector. Little did we know it would be the dominant PC game graphics standard for years.



Microsoft's original *Flight Simulator* was popular among office workers, because it could be passed off as a "simulator" rather than a game.



Above top: The original *Doom* is still a blast to play, even if it does look dated. Above: The Commodore 64 was incredibly successful thanks to its affordable price.



own games and set the precedent for development teams that could work independently of the companies actually building and selling computers.

ALL GOOD THINGS

As both quality assurance and legal regulation surrounding PC gaming were still in their infancy, low-quality games and rushed clones of popular titles flooded the market. From 1983 to 1985, interest in console gaming plummeted. Some feared that PC gaming would be the next to go, the entire notion of digital games written off as a one-time fad.

Fortunately, PCs are more useful than consoles, and 1983 onward also saw renewed interest in the use of computers for educational purposes. More PCs in households and workplaces meant more potential systems for games to be played on, and the industry was quick to act. IBM released its DOS-based Personal Computer, a game changer within the computer industry that ultimately set the standard for modern PCs; indeed, the IBM PC's primary competition was Apple's original Macintosh computer.

Computer gaming became a booming industry, with companies like the fledgling

Microsoft producing popular titles such as *Microsoft Flight Simulator*. Unlike today's target audiences of families and young people, office workers of corporate America were the people buying and playing games, as PCs slowly started to become commonplace in white-collar workplaces. What better way to slack off than load up a copy of *Dig Dug*?

DOS computers started selling like hot cakes. With competition in the market heating up, IBM wasn't able to keep its prices high for long. A wave of IBM PC clones forced prices down, opening up PC gaming to a wider audience. Although still considered a novelty by many, it was undeniable that PC games were beginning to achieve mainstream appeal, with Electronic Arts reporting that many of its customers spent as much as 20 percent of their screen time playing games; even those who had purchased their PCs for unrelated purposes.

Unfortunately, before the end of the '80s, the console market struck back with its coup de grace: the Nintendo Entertainment System, more commonly known as the NES. The console's vast success in Japan and beyond saw console gaming surge back into popularity, with revenues outstripping the modest successes of the computer game market. Still, the humble PC had two more



tricks up its sleeve: VGA graphics and online multiplayer.

VIDEO KILLED THE EGA STAR

Let's start with why VGA was so important. Before the dawn of the Video Graphics Array, computers—and, by extension, games—had run through several different industry standards for dedicated graphics. In 1981, IBM had the CGA [Color Graphics Adapter], which was superseded by the EGA [the 'E' stands for Enhanced].

But VGA offered a serious upgrade, with superior resolution, greater color options, and improved refresh rates. Its 4:3 aspect ratio still kicks around to some degree, and the vast popularity of VGA (and, later, the upgraded Super VGA) among third-party manufacturers made it the new gold standard for PC graphics. Widespread adoption of VGA's 640x480 resolution—laughable today—happened in just a few short years, with IBM shelving plans for a new display controller, the XGA.

Improved graphics coincided with the introduction of dedicated PC soundcards from manufacturers such as Creative Labs [which is still making kick-ass soundcards to this day], and PC gaming saw a revolution. By the time we arrived in the heady yet poorly-dressed '90s, DOS systems running VGA graphics dominated the computer game market, paving the way for a new kind of game: the first-person shooter.

Texas-based developer id Software was a newly minted company in 1991, but the improved graphical capabilities

of PCs enabled it to make *Hovortank 3D* and, a year later, the hugely successful *Wolfenstein 3D*. These are the games credited with forming the template for the modern first-person game, some of the first games to place players in a fully 3D world, navigated on a horizontal plane.

Wolfenstein 3D is still fun to play—in fact, 2017's *Wolfenstein II: The New Colossus* featured an arcade machine with a fully playable parody called *Wolfstene 3D*—and it's somewhat surprising how many features of the game have endured in the 30 years since its creation. The first section of the game was available to play for free as shareware, with the full experience unlocked via purchase; a model that would become game demos as we know them today. *Wolfenstein 3D* was also one of the first titles to properly utilize texture mapping, the technique by which detailed textures can be applied to 3D models within the gameworld.

The original *Doom* followed soon after, and achieved even greater acclaim. It wasn't hard to see why: further improved graphics and the fast-paced gameplay fans of the series have come to love (speaking of which, if you haven't played *Doom Eternal* yet, what the heck are you still reading this feature for? Go play it!). *Doom* was a technical improvement over *Wolfenstein 3D* in just about every way, but crucially it offered a multiplayer element.

BRING YOUR FRIENDS

Doom had a variety of multiplayer options, from two-player local co-op to four-man

deathmatches over dial-up Internet. One *Computer Gaming World* reader wrote in to describe it as "the quickest way to destroy a productive, boring evening of work." Of course, it wasn't the first game to offer multiplayer options (remember *Tennis for Two*?), but it was an important milestone in the development of online PC gaming, which has since expanded into a multi-billion dollar industry.

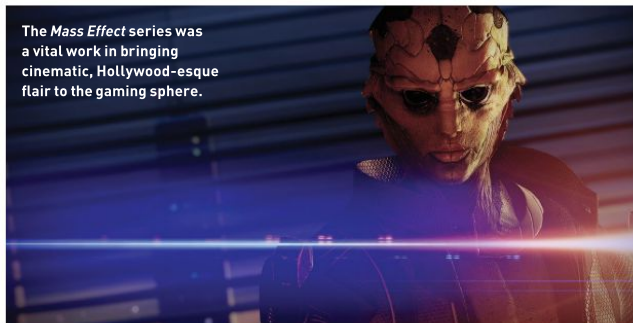
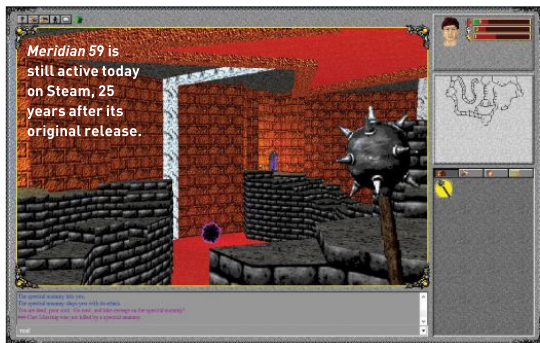
Network play actually dates back to the 1970s, when a group of coders got in trouble for hogging the available RAM of the University of New Hampshire's interconnected network of PDP-11 minicomputers in order to play their home-brew digital *Dungeons and Dragons* campaign. The PDP-11 network allowed multiple users to log into the game from separate terminals, all accessing a segment of shared memory on the university's mainframe computer.

The university banned the games, but the seed was planted—why drag yourself to a friend's house to stare side-by-side at the same screen, when your games could connect remotely? Although the Internet was technically created in 1983, it took a few years before it could become a viable platform for online gaming. Multiplayer games set up to run on specifically networked systems grew in popularity throughout the '80s, leading to the rise of the local area network, or LAN, party.

Spectre, released for the Apple Macintosh in 1991, was a simple game that saw players take control of a little tank, fighting other tanks with missiles and bombs. Using the AppleTalk network service, up to eight users with their own Macs could connect in the world's first LAN game, enjoying hours of fun blasting each other in *Spectre*'s virtual battlegrounds. Some of *Spectre*'s success was attributed to the way it displayed other players' usernames above their blocky avatars; if you wanted to gang up on the cocky player scoring too many points, it was easy to do so. If you've played a *Worms* game in the past decade, you'll know exactly how important that feeling is in fostering connections between players.

With the launch of the World Wide Web in 1991, the industry was ready to expand into bigger multiplayer endeavors. *Neverwinter Nights* was one of the first to set the tone, establishing 96-player servers with chat rooms and persistent world states. One player assumed the role of dungeon master, commanding dozens of other players as they moved through the online world.

With dial-up Internet reaching more and more homes, the pressure was on to bring online elements to games. *Doom*'s



local co-op success made it an obvious candidate, with id Software adding an online multiplayer update a few years after its release. Titles such as *Meridian 59* further expanded on the template for online games, introducing online guilds and direct player-to-player messaging. *Meridian 59* is also considered to be the first online PC game to require a regular subscription to play.

The real turning point for online PC gaming, as any gamer who was alive in the '90s will tell you, was *Quake*. Building on the *Doom* multiplayer blueprint, *Quake*'s 1998 *QuakeWorld* update offered fierce deathmatches perfectly pitched for online play, whether for settling friendly scores in 1v1 duels or just messing around with friends on the weekend. *Quake* was also notable for its early adoption of OpenGL 3D, an intriguing new programming interface for rendering 3D graphics.

NEW LOOKS

Approaching the turn of the century, game graphics kept making leaps and bounds forward. As computers became more powerful, gamers wanted more from their games; APIs such as OpenGL and DirectX were suddenly sought-after mediums for

creating advanced, hardware-accelerated 3D graphics. *Quake* was swiftly followed by Valve's massive breakout hit *Half-Life*.

Half-Life was unique in its insistence on delivering plot beats to the player in real time, rarely taking the player out of protagonist Gordon Freeman's first-person viewpoint. The graphics were good enough that scripted events and bombastic set-pieces could replace the prerendered cutscenes that had become the industry's preferred means of narrative exposition. It was a revolution, and the birth of powerful but more intuitive game development tools, like the legendary Unreal Engine, saw gaming enter the 21st century riding a wave of momentum.

Nvidia and AMD were already locking horns in the graphics card production stakes, and the growing popularity of home PCs (along with the Internet providing the information needed to build your own system) saw the GPU industry boom. No longer were developments in computer tech driving the PC gaming industry; now, gamers drove innovation forward with their insatiable desire for bigger games with better graphics.

The early 2000s saw a number of hit games land on PC. Although massively

multiplayer games were around before *World of Warcraft* kick-started a cultural movement—*Neverwinter Nights* was one of the earliest, notably followed by *Ultima Online* and *EverQuest*—Blizzard's tour de force drove new interest in PC gaming from tabletop gaming circles and beyond.

Successful multiplayer shooters like *Counter-Strike* continued to make a case for online PC gaming, with consoles (the PlayStation 2 and original Xbox) struggling to keep up. It wouldn't be until the mid-noughties that a new console generation managed to secure wider adoption of online play, while PC gamers enjoyed multiplayer classics like *Battlefield 1942*.

Multiplayer was in vogue; by 2010, every game needed a multiplayer mode. Many were produced largely with competitive multiplayer in mind, while others tacked on competitive play as a half-assed afterthought (looking at you, *Bioshock 2*). Popular multiplatform titles such as *Call of Duty* began to shift away from narrative solo experiences and toward the high-octane bursts of online deathmatches.

SUMMER SALES

Platforms for selling PC games had to evolve. As PC gaming expanded, developers needed easier ways to get their titles into homes, something faster than mail-order catalogs and cheaper than producing thousands of physical copies. Steam was already around (it was founded by Valve in 2003) but once improved Internet access became the norm and the days of the dial-up connection died, home broadband enabled the platform to take over the market.

Competitors arrived in the 2010s, following a blissful few years of Steam maintaining almost complete dominance over the digital distribution market. Some crashed and burned—remember Impulse? Yeah, us neither—but some were able to persist, usually with a clever



Although it features very little actual gameplay, indie darling *Gone Home* has been hugely influential.

angle. *The Witcher* developer CD Projekt offered DRM-free games for digital purchase on GOG.com, while Blizzard adapted its old Battle.net game launcher to sell more games, including some from its partner company Activision.

While some major publishers opted simply to feature their new games as timed exclusives on their own digital storefronts (such as Uplay and EA Origin), others sought to properly challenge Steam. The Epic Games Store is a plucky newcomer to the digital game distribution industry, but is already ruffling feathers with its free game giveaways and boosted profits for developers.

It's a fascinating situation, especially when the indie game scene gets involved. Developing games for PC has never been easier, and there are far fewer hurdles compared to creating an indie game for consoles, making the PC the perfect medium for a new wave of experimental and innovative game experiences. Epic's decision to take a smaller cut of profits has driven many small and aspiring dev teams to shift away from Steam.

INDEPENDENT LIVES

Those indie titles are incredibly important, as they are changing the boundaries of what it means to be a game. The triple-A PC gaming industry has moved away from innovation and toward perfection, constantly chasing the "next generation" of the same tired analogs. We're not disparaging new features like ray-traced lighting or advanced destruction physics, but technological improvements now seem more important than meaningful experiences for players.

Indie games, meanwhile, aren't afraid to think outside the box. Whether it's the

SPORT OR SLOUCH?



League of Legends has a huge esports scene. Pre-COVID, packed arenas like this were common.

The esports world is a strange beast. Competition is so ingrained in human nature that competitive games have been around since the early days of *Spacewar!*, and real-world tournaments for arcade titles such as *Street Fighter* were popular across the US and Asia throughout the '90s and the early 2000s. The huge success of *StarCraft* in South Korea saw major matches televised for increasingly significant cash prizes. Fighting games, shooters, and MOBAs (multiplayer online battle arenas, such as *League of Legends*) dominated the market, and still do.

Only in the past decade, though, has the esports scene achieved widespread appeal. Major publishers started setting up their own events, while streaming platforms such as Twitch offered new routes into the competitive scene.

The esports formula is something many developers have tried to tap into,

with varying degrees of success. For every *Overwatch* and *Valorant*, there is (or was) a *Battleborn* and a *Lawbreakers*. Building the perfect esports game is an art that seemingly has yet to be mastered, but that hasn't stopped the games industry from making its money.

It's been a lot of money, too. The esports industry surpassed a billion dollars in net worth in 2020, and is showing no signs of slowing. COVID-19 actually led to an uptick in interest, with more people picking up gaming in lockdown and turning to professional streamers for advice.

The debate as to whether games can be considered a real sport will probably continue to rage for a few more decades, despite esports becoming increasingly prominent on platforms like ESPN and even being recognized by the Olympic Committee in 2017. What do you think?

tightly-controlled storytelling of *Gone Home* and *Oxenfree* or the potential for players to create their own stories in *Among Us*, indie games offer a tantalizing peek into the future of the PC gaming world. Mainstream gaming has become a cash-spewing behemoth; the indie development cycle is a route to break free of corporate obligations, but it comes with its own struggles and pitfalls, too.

Where does PC gaming go from here? It's impossible to predict. The industry has become huge, with millions of gamers and creators looking for their voices to be heard. As we edit this feature, Apple and Epic Games remain locked in a legal battle that could redefine the limits of

the gaming industry as a whole, while political bodies are starting to take real interest in games as a form of media and the influence they can hold over the public.

One thing is certain: The money will keep flowing. The industry keeps growing, and games keep looking and playing better. Advances in AI promise to bring a new level of complexity, while augmented and virtual reality offer immersion on a whole new level. Cloud gaming is the next frontier, but it looks to take the hardware appeal away, so we at *Maximum PC* obviously can't endorse it. We hope home PCs can keep getting smaller and more powerful, and we hope people like you keep building them to play games on. ☺

gamesradar+

One-stop destination for games, movies, TV, and more!



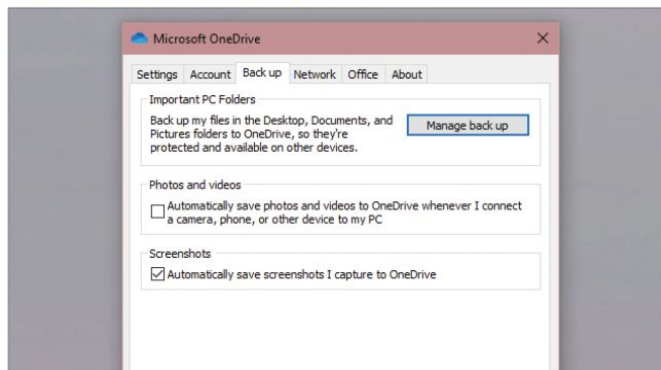
New Channels: Movies, TV and Cool Stuff!

www.gamesradar.com

HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

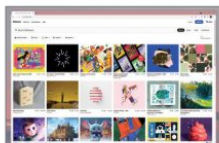
TIP OF THE MONTH



SYNC SCREENSHOTS WITH ONEDRIVE

If you're working between two systems and are awkwardly transferring screenshots via a USB drive, email, or such, this tip should help. Right-click the OneDrive icon in your taskbar and go into its settings. At the top, click "Back up," then click the "Screenshots" checkbox to automatically save screenshots across your OneDrive account. Hey presto—just like that, all your print screens appear on each of your systems.

MAKE – USE – CREATE



60
Make a product
mock-up in
Adobe Photoshop



64
Have more fun
with your Oculus
Quest 2



66
Mod your
PC with 3D-
printed parts



SAM LEWIS
STAFF WRITER

GETTING SPOILT

As I mentioned in the previous issue, I've been lucky enough to receive my first headphone DAC/amps to review, but with that comes a major gripe. When it's time to send them back, I am definitely going to have to buy my own. Once I've experienced something that good, I can't settle for anything less. This job is sure going to cost me a lot down the line, because I'm lucky enough to be around the latest tech all the time. The extra detail that's picked up by the DAC/amps is something that I cannot live without, unfortunately; it's just too good. I recently had to send back the VR systems I'd been looking at, which was a sad day. And, yes, you guessed it, I now need a VR system in my setup, too. Luckily, I used them as much as I could while I had them in.

I also mentioned in last month's "Lab Notes" that I've retrofitted a budget Apple CarPlay system using an Amazon Fire HD tablet in my car. It works great, but I need to overcome one problem: I can't charge my tablet at the same time, due to the USB C port being taken up by the Apple CarPlay dongle. I've tried a USB C hub, but it doesn't allow for pass-through charging. Grrr. I'm going to spend this month trying to bypass this and hopefully, by next issue, it'll be sorted.

submit your How To project idea to: comments@maximumpc.com

AUTOPSY

THIS MONTH WE DISSECT...

Time heals all wounds, but probably not our little Mi Watch—that's going to take some effort.



About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.



It's usually difficult to repair the screen of a smartwatch that opens via the back, and the Mi Watch is no exception.



Last year's Chinese Mi Watch bore more than a passing resemblance to another watch made by a certain lifestyle company in Cupertino. With this version, Xiaomi has switched to an all-new, circular design.

Xiaomi Mi Watch 2021



A Torx T2 easily opens the case—no glue here, thankfully.



With no soldering keeping the battery down, it makes for a swift replacement.



BACKGROUND

They say time makes fools of us all, but that hasn't stopped Xiaomi from working around the clock on a totally redesigned Mi Watch. Does its newest timepiece earn a place on your wrist? Tick tock, only this teardown can tell.

MAJOR TECH SPECS

- 1.39-inch (35mm) circular AMOLED display with 454x454 resolution
- 11.8mm thickness at 32g
- Wireless charging
- Accelerometer, gyro, heart rate, barometer, compass, SpO2 (blood oxygen testing)
- Water-resistant to 5 atmospheres
- Bluetooth 5.0

KEY FINDINGS

- We're not seeing major changes in terms of hardware components over last year's square Chinese version of the Mi Watch, but the new design direction is evident. This watch even grew another button, perhaps to keep up with Samsung. Maybe there are only so many ways to shape something that straps to your wrist. Let's look inside....
- Even though it's water-resistant up to 50 meters, this Mi Watch opens with a Torx T2 bit from our Mako Driver Kit and a little prying. It's nice to be reminded that "waterproof" doesn't have to mean "glued together." Our first look inside is encouraging, too, as we spot some standard Phillips screws; though it would have been even better if only one screwdriver was needed.
- A bit of prying frees the battery. It's great to see this common repair prioritized, with a modular connector, no soldering required. The battery is a 1.62Wh (420mAh at 3.85V) Li-ion block, which charges wirelessly. Xiaomi claims it can power the watch for 16 days, or 50 hours during sports. The bottom part of the watch case also bears a cable assembly with a tiny vibration motor, the heart rate and SpO2 sensor array, a barometric sensor, and a MEMS mic. Behind the sensor board is a Texas Instruments AFE44130 biosensor analog front end module.
- Just two Phillips screws secure the mainboard—twist them out, and the board floats free. After removing the mildly glued-in button cable, we find an Ambiq Micro AMA3B MCU and a Bosch Sensortec BMI270 three-axis accelerometer/gyroscope on the top side of the board, while the bottom side features an STMicro STM32L4R92I6P microcontroller, Paragon PN26Q01AWSIUG 1Gb NAND flash memory, a geomagnetic sensor (likely), electronic compass, and an SGMicro SGM41562 Li-ion battery charger with power path management.
- It's been a pretty good experience so far, but here's the part we've been avoiding. To free up the display assembly, we had to use a heat gun at about 300 C and a razor blade, causing the screen some damage. We also gave playing cards a try, only for the display layers to separate. Then the actual screen shattered in our hands. The last things to come off are the two side buttons, held in place by tiny metal washers on the inside.
- Repairability Score: 5 out of 10 (10 is easiest to repair). The opening procedure is simple and glueless. Connectors are modular and don't overly overlap. The battery is easily accessible for repairs. Opening requires a somewhat uncommon T2 Torx driver, but Phillips screws grace the inside. Many components are grouped together and can't be replaced individually. Display removal seems impractical and repairs will probably require replacing the watch casing. 🔧

Make a Mock-Up in Photoshop

YOU'LL NEED THIS

ADOBE PHOTOSHOP CC 2018 ONWARD

To view compatibility visit: <https://helpx.adobe.com/photoshop/system-requirements.html>.

A MOCK-UP ALLOWS YOU TO SHOWCASE your designs and brandings on physical products. It's a great way to take a look at how your creations could end up looking. Designs can look good flat, but where they shine or fall is when you take that digital design into the real world. Mock-ups are the in-between, where you can visualize your ideas and show off your creative intentions.

There are a lot of premade template design mock-ups online for you to download and drop your logo right into, but sometimes you just can't find exactly what you're after. Or in other cases, you're creating something completely custom, where you want to see what a design would look like on an item you already own. For this tutorial, we are going to presume you've made a logo and are applying it to a cup for advertising purposes—you've just opened up your first coffee shop, say (original idea, we know). Regardless of your exact intentions, it's great to add mock-ups to a portfolio to better visualize your concepts. The key here is to merge your logo or design with the base image in a natural way; this is to keep the product looking professional, as though you designed the base image, too. —SAM LEWIS



1 GATHER YOUR IMAGES

You're going to have to use your imagination here, because we are going to make a *Maximum PC* coffee cup; who wouldn't want one, right? Using a great license-free image website called Unsplash (<https://unsplash.com>), we found a base image for this tutorial. The thing you have to keep in mind when creating a mock-up is that you don't want it to look like a mock-up, as ironic as that sounds. You want viewers to look at it and believe that your added design is part of the original image. We will achieve this using an array of layers and blending effects.

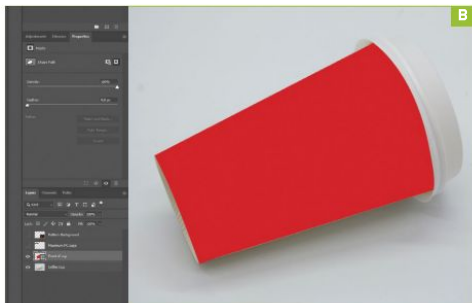
» We have our image (from Brando Makes Branding, on Unsplash) and our *Maximum PC* logo on standby [Image A]. To spice things up a little, we're also adding a patterned design to our cup, courtesy of Michael Dzedzic on Unsplash. The first step is, of course, the mandatory labeling stage. Keep things organized and you won't pickle your brain later on in the process. Trust us, we have been in that place plenty of times, and we don't want you to experience that.

2 PICK UP THE PEN

Once you have everything organized, you can start delving into your mock-up. To create your template, use the Pen tool. If you don't already know, it's a simple selection tool. You can fill, stroke, or make selections from the shape you draw; if you're new to Photoshop, it'll soon become your new

best friend. The keyboard shortcut to the Pen is simply P [thank you, Adobe]. To make sure you are creating a shape for this instance, go to the top of the page, and where it says "Path" next to the pen icon in the top bar, click the drop-down box, and select "Shape." Now you can start drawing. The Pen tool takes time to get used to, so practice a few times before committing—you can always add or remove anchor points after drawing your shape, but it can get a bit tricky.

» You are going to be drawing the front of the coffee cup, to make a shape out of that. It's best to start in a corner. The Pen tool likes to draw curves; if you prefer to use a straight line, click on a point, holding Alt to cut off a handle. A handle is a bar that you can pull and adjust to create a curve in your drawing. To do this, click and hold, move your mouse around until you get the perfect angle, and add more points into your line if needed to get a smooth, accurate curve. Just remember, it can get awkward, but it's like any tool—with enough practice, you will get handy with it. Once your shape is drawn and you want to move a point, hold Ctrl, then click on a point. You can drag this wherever you want and even adjust the curve again using the handles. We colored our shape red [Image B] just for clarity, but you now have your base template shape.

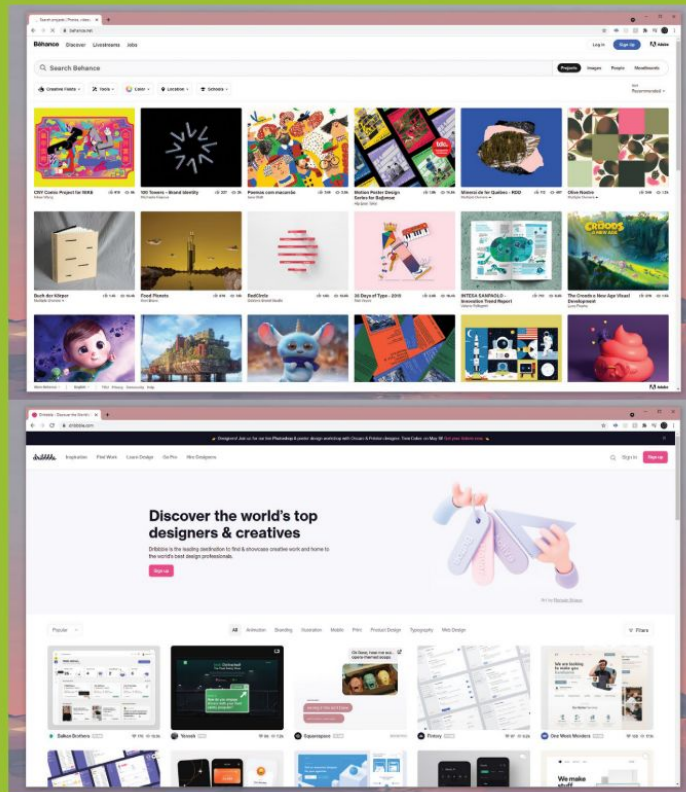


SHOWCASING WORK: BEHANCE VS. DRIBBLE

These two platforms are great community engagement areas, where you can display your work, find inspiration, and look for designers yourself. Particularly for freelancers, they're great places to make a name for yourself, and you can use the sites as an online portfolio. Building a name online is just as important as having a physical reputation, especially in the way the world is constantly pushing toward digital media. Even if you are yet to start creating your work, looking on these sites may give you that spark to get into this as a hobby or even lead to a career in design.

We'll start with Behance, which is mostly used for larger projects and a collection of designs. You can stitch multiple images and mock-ups together to create a large detailed post about your work. Animations can even be added to give your work extra flair. There are lots of customizable options and features that lend themselves more toward a portfolio or a large project than, say, a one-off design. Behance has a huge variety of work types, from logo creation, brand identities, and publishing artwork to animation design and architecture.

The issue with Behance is that the ability to create a highly detailed and personalized portfolio also means it's not a simple process. It requires a lot of work to build these pages, but that energy is worth it in the long run. For people wanting a quicker release of their designs into the world, Dribbble may be the more user-friendly approach. Fortunately, Behance is also free; it's owned by Adobe and thankfully hasn't fallen



into a monthly subscription service, so it's a great place to start to build a name for yourself.

As mentioned, Dribbble is a quicker alternative to Behance, following a much more cookie-cutter format than the customizable depths Behance offers. Think of it as more of a social media platform for designers. As with Behance, it has a huge network, so there will be plenty of new work being uploaded daily. You can quickly upload an image with some text, and that's it. It's super-easy to use, which makes it a

faster process. On the downside, Dribbble is more heavily influenced by visual and UI design, which can make it harder to get your work seen if you are more niche. Trends can be a problem, too, as they tend to periodically suffocate the site, making it harder to be seen if you aren't jumping on the most current bandwagon. Due to its fast and easy-to-use nature, it isn't as customizable as Behance for producing more in-depth cases of work.

The real question is what feels more suited for you. If time is of the essence and

you need to get your work out there quickly, and aren't fussed about how exactly it is displayed, Dribbble is a great shout. It's a vibrant community, where you can interact with others and keep a keen eye out for new inspiration. The same can also be said of Behance for its variety and community, but not so with regard to speed. If time is on your side, you can produce a very impressive personalized portfolio on there to showcase your work, and this may be a better path to take if you're serious about going professional.

Setup and supercharge your Raspberry Pi with our guides and then discover inspiring projects that you can get started with today

Setup and supercharge your Raspberry Pi with our guides and then discover inspiring projects that you can get started with today



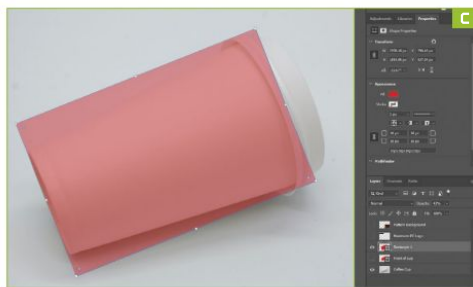
180
PAGES OF
AWESOME
PI PROJECTS

Smart home ideas • Operating systems • Pi gaming



www.magazinesdirect.com

Or get it from selected supermarkets, newsagents, or bookstores



3 SMART WORK

Now you need to create a Smart Object and make a mask from the shape you've just created. Go to the Shape tool and select the Rectangle tool from the left-hand side. Draw this rectangle roughly over the area you will be adding your mock-up to, as shown [Image C]. To make life a little easier, color it and reduce the opacity, so you can see the base image underneath.

» After you have drawn your rectangle, you can rotate it to fit around your shape. Try to get it as close as possible to the Pen-drawn shape you created. Now apply some smoke and mirrors, by changing this shape into a Smart Object. Right-click the rectangle shape layer and convert it to a Smart Object. To help with organization, rename this layer to "Front smart object," and right-click the layer to choose a color; this helps quickly identify this Smart Object [Image D]. Next, transform this layer to fit more closely to the Pen-drawn shape. Hold Ctrl-T to get the transform options. Using the Warp and Distort tools, adjust your rectangle as close to the front of your design as possible.

4 FINISHING TOUCHES

Now for some masking. While clicking on the Smart Object layer, hold Ctrl, and click the thumbnail icon in the Pen-drawn layer (front of cup layer, in our example). Then below the layer windows, click the square icon with the circle center ("Add layer mask"). Once done, whatever you place in the Smart Object layer won't spill over the Pen-drawn shape you created at the beginning. This ensures your design sticks to the confines of where you want it. Speaking of your design, let's add it. First, take the color out of the design you created—unless you are completely filling the space with the design. Open the Smart Object layer by double-clicking the thumbnail of the layer. This opens a new window where you can place your design [Image E]. As we rotated our rectangle earlier, our design positioning is slanted, but fear not, as you can just rotate your design to fit.

» We placed the circuit board pattern in the background and applied an invert to contrast it from our logo. We placed the



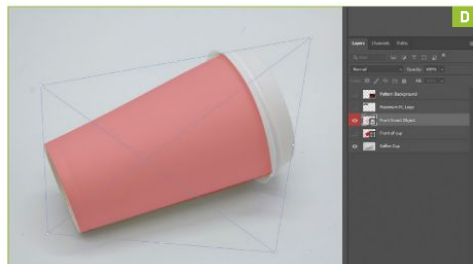
logo horizontally and in the center of the design. Once you have chosen how you want to lay out your designs, hit Ctrl-S to save. This applies the changes to your main artboard. Head back over to the original window and see your creation.

» For some finishing touches, we reduced the background's opacity to around 40 percent, as it was too overwhelming in the final image. We then added some text following the same angle as our logo for an extra touch [Image F]. Before we go on, this is not a design tutorial, so please don't slate our aesthetic chops! This is a Photoshop tutorial; we would spend much more time designing this if we could, we promise. Next, to add some more accurate shading effects, we altered the levels slightly using the sliders to make it a little darker, and applied a multiply effect on the layer to allow for some of the cup's shading come through into the foreground.

5 MOCK-UP MASTERY

At this stage, you are free to edit and alter the image to your liking. Add more filters, change your design, play around with the layout to get what you want. This final mock-up should be a great place to see if your design works or not. It may show you what changes could be made to your original design in order to make it work in the real world.

» The great thing about mock-ups is that you can save them as a template to use again for future projects. Simply save it as a new file, and remove all the designs in that version. Then, for the next project, all you have to do is drag and drop your design in, and position it correctly. All the hard work has already been achieved. To practice, apply this method to an image of any other object, and see what your designs look like on a range of different items. Hopefully, this tutorial will assist you in showcasing your inner creativity. ☺



Have More Fun With Your Oculus Quest 2

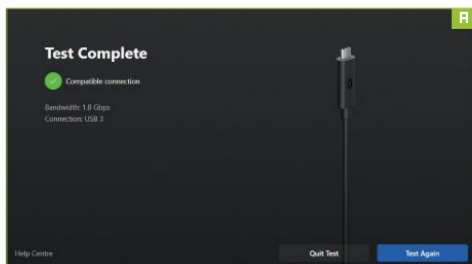
YOU'LL NEED THIS

OCULUS QUEST 2

See our review [pg. 80] for more details.

THE QUEST 2 DELIVERS a maximum bang-for-the-buck VR experience, but that's not to say it's perfect. For sure, the headstrap is bad, but that's why they sell the Elite option, which should be on your wish list, especially if you have to share it with your different-head-sized family or friends. The built-in speakers are fine, but for an even more immersive experience, you'd want to invest in some good wired alternatives using the built-in audio jack.

It's these sort of low-hanging-fruit tips lesser publications would stretch out for page upon page, but there's no such BS here at *Maximum PC*. So, let's look at how to get the best from your Quest 2 and sort out some common issues. —NEIL MOHR



1 OCULUS LINK

For the smoothest PC gaming experience, you'll want to shun Oculus Air Link—discussed below—and opt for the cable-based Oculus Link. Oculus demands a ridiculous \$90 for the official 5m USB-C cable, but it is damn clever, being fiber optic with USB-C adapters integrated at either end. So, don't dismiss it out of hand as a price-gouging exercise—there's technology in them thar cables.

» However, you can find 5m USB-C cables for around \$20 (make sure you read the reviews before buying). We tried the Cable Matters Active 5m cable and recorded 1.6–2.1Gb/s speeds, which easily passes the test. People have reported various Oculus software updates (largely v25) “breaking” USB-C cables—ones that used to pass the speed test stop passing it, for no obvious reason—to the point where Oculus had to enable USB 2.0 connection speeds, even though this is darn awful visually.

» We've experienced something similar; the Cable Matters cable was plugged into a USB 3.1 port that reported 2.1Gb/s at one point, then weeks later, it dropped to 500Mb/s for no obvious reason. Switching to another port had it running once again at upward of 1.6Gb/s.

» It's well worth speed testing all your USB ports, so you know which are viable, because individual USB bus controllers have their own performance and bandwidth. Plus, as usual, update your chipset drivers and disconnect unnecessary USB peripherals to maximize bandwidth on that bus.

» You can check which USB bus your Oculus is connected to within Device Manager. Locate your Oculus under “Oculus Device” or “Portable Device” (when it's on and connected), then select “View → Devices by connection.” Here you can ensure you're using a USB 3.x port, and no other devices are sucking down the bandwidth [Image A].

2 OCULUS AIR LINK

We originally planned to explain how to get the most out of Virtual Desktop—the third-party app for wirelessly connecting the Oculus range—but then Oculus announced the v28 software update that adds its own Oculus Air Link wireless connection. It's likely Air Link will supplant Virtual Desktop as the primary way to enjoy Oculus wirelessly, but these general wireless setup tips apply to both systems.

» A Wi-Fi 5 (802.11ac) router is essential. It should be in the same room as your Oculus, and your PC should be directly connected to it with an Ethernet cable. People report that Wi-Fi 6 (802.11ax) seems to make little difference, so don't worry about a router upgrade. We've also read (but not tested) that using PC-based dongles to create a local hotspot isn't always great, possibly as they have fewer transmit antennas than decent routers.

» If it's a mesh router, ensure this feature is turned off. Ideally, switch it to 5GHz mode only, or split the SSID to separate 2.4GHz and 5GHz, and ensure the Oculus is connected to the 5GHz SSID. If you have other 5GHz routers, it might help to turn these off if possible, or ensure their channel selection isn't close to the Oculus router's channel range to avoid interference. This avoids the headset switching between the 2.4GHz and 5GHz bands, as a 2.4GHz connection won't be fast enough.

VIDEO PLAYBACK

We all know 3D films on TVs were a bust, but 3D on VR headsets is another thing—it's like actual 3D. The Quest 2 isn't ideal, because it's relatively heavy, so we're not sure you'd want to watch entire films, but the option is there. How do you enjoy films and video on the Quest 2, though? We suggest Pigasus VR Media Player (\$5), which supports local but also, importantly, remote streaming via SMB shares and UPNP/DLNA sources. It didn't have any issues playing the h.265 6K 60fps 3D video we streamed with it.

If you find you're having issues playing PC-based content, you'll want to ensure you have the Microsoft Store Media Foundation Codecs For Windows 10 for HEVC/H.265 installed. The easiest option to solve this is to head to https://codecguide.com/media_foundation_codecs.htm and snatch the HEVC/AV1/VP9 codecs.

» Finally, ensure the router is around three feet off the floor and is in line of sight. You'll want to connect at the fastest speed possible: 866Mb/s Wi-Fi 5 (802.11ac) or 1,200Mb/s Wi-Fi 6 (802.11ax). Our experience shows that even being in the same room as a 802.11ac router can limit you to 535Mb/s.

3 AUDIO SHENANIGANS

It's worth being aware of how Oculus, Windows, and Steam handle audio streaming, and how you can select what your PC plays. At some point, you'll lose audio output on your PC or Oculus, and you'll be left wondering what's going on.

» The quickest answer is to check the Windows audio settings. Click the "Speaker Notification" icon, bottom-right, then click the "Up Arrow" icon. This lists all available audio output targets. It should offer something like: Digital Audio (S/PDIF), Speakers (Steam), Speakers (High Def... PC), Headphones (Oculus), Speakers (Steam Mic), plus any monitors, and so on.

» This should be set to Speakers (High Def...). If you come back to your PC and there's no sound, it's likely this has changed. Using the Steam VR settings, you can mirror audio on your PC and Oculus, which can be helpful for troubleshooting audio.

4 TWEAK SETTINGS

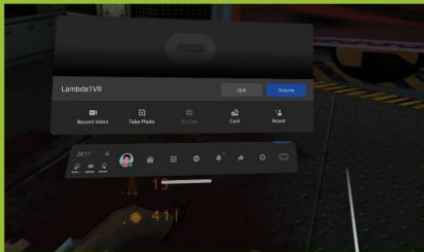
It's good to know where your main display settings are, as the Oculus refresh rate controls aren't obvious. If you're interested in the 90Hz and 120Hz capabilities, connect your Quest to your PC—we had to ensure Air Link was disabled—and select "Device → Quest 2 and Touch" in the Oculus Software. Scroll down to the "Graphics Setting." Here you set the overall refresh rate. Be aware that this reduces the available resolution from 4128x2096 to 3712x1872 at 90Hz and 3104x1584 for 120Hz. Also be aware that Oculus-based games have to directly support these higher refresh modes, and not many do.

» It's likely you're planning on running PC games via Steam VR, so it'll be worth getting acquainted with the Steam VR settings. Fire up Steam VR from the Oculus Link screen or directly from desktop Steam. On first run, you're taken to Steam Home and given a tour. Press the left system button to open the Steam VR settings. If you're not a fan of the awkward and time-consuming Steam Home, you can opt not to load this—"Settings → General → Steam VR Home → Off"—and use the basic settings-based menu instead. If you do this when the Steam VR "land" appears, press the left system button to open the menu. Access the settings via the Cog icon. You won't need to access these too often, but it's worth going over Controller Bindings, Advanced Display settings, and the Audio options [Image B].

5 TRY THE GLASSES SHIM

Your Quest 2 comes with a shim insert to enable glasses-wearing folk not to miss out, pushing the device away from your face slightly. We use our Quest 2 both with and without

SIDEQUEST



The Oculus Store is slick but boring, so visit <https://sidequestvr.com> and install SideQuest. It's an independent development hub that takes advantage of the fact that the Oculus Quest can be switched to Developer mode and have APKs (Android program packs) side loaded—like most Android devices—for you to enjoy indie-style games.

It's totally legal and even Oculus is helping to promote certain games hosted on SideQuest as part of its App Lab scheme. This is largely because getting hosted on the official Oculus Store is tricky for small devs. Follow the "Get SideQuest" link for full instructions and download links for Windows, Apple, Linux, and Android.

What's cool is that the SideQuest geniuses have ported *Half-Life 1 (LambdaVR)*, *Quake 2*, *Doom VR*, and *Doom 3* to VR because their source code has been released. You need to own the original games, though, for the resource packs. There's way more to SideQuest, of course, and you should also check out *Ancient Dungeon*, *Pavlov Shack*, *Hyper Dash VR*, and *Gorilla Tag*, to name just a few.

glasses and leave the shim in. It potentially allows some light in (not that we've noticed), but we like the shim because if you look down, you can see the floor though a tiny crack by your nose. This enables you to reorient yourself in the room without having to use the pass-through mode or enabling the Guardian grid.

6 ADJUST THE STRAP CORRECTLY

The default headstrap is less than ideal but, for many, it's all you've got to work with, so ensure you're using it correctly. The trick is to loosen the top strap and ensure the back strap is right at the base of your skull. This helps to offset the weight of the headset. Now, go enjoy some VR [Image C]!



Mod Your PC With 3D-Printed Parts

YOU'LL NEED THIS

3D PRINTER

You'll also need a drill and drill bits, M3 nuts and bolts, and possibly some sandpaper and spray paints.

THERE'S A VAST NUMBER OF WAYS in which you can customize a system: using vinyl or paint, installing a full hardline loop, or even modifying the case using hand tools to create a new look. They're all great ways in which to start modding, but over recent years and thanks to its growing popularity, 3D printing has become an excellent choice for adding a personal touch to a build.

The addition of 3D printed parts can really impact the final look of a system, taking it from mediocre to standout. When there are so many builds based in the same cases, using distro plates or generic layouts, things can get a bit dull. Taking a step away from the norm or current trend can be daunting, but with a little planning and a 3D printer, you can step out of the shadows of a generic build and into a truly modified system.

We are going to take you on the start of this journey, with a simple guide to 3D-printing a reservoir mount, and once you have the basics nailed down, who knows what you will be designing and printing for your next build? —KRIS BUTTERILL



1 PRELIMINARY POINTS

Planning is the key to any build; this counts for the aesthetics, too, even at the hardware stage. If the idea you have for a layout is not physically possible with the hardware at your disposal, it might be time to re-evaluate. The use case of the system will always be the priority, but exchanging certain components may offer the same performance and quality, while offering greater flexibility in terms of how the system can look.

» Our guide features the roomy Be Quiet! Dark Base 900 Rev. 2 chassis, which was chosen with this particular mod in mind; we want to incorporate dual Alphacool Cape Corp Coolplex reservoirs, and need a case with plenty of room to show them off.

» We'll be mounting the reservoirs to the hard drive cage slot covers. As we won't be utilizing any of these bays, it makes sense to fill this area with the reservoirs out as a focal point.

» Mounting reservoirs here makes for a fairly straightforward tutorial, but you may want to mount to a different surface, and given the huge number of combinations and cases that are available, each build will vary, so plan accordingly.

» Before we look at our custom mounting solution, we must get our system nearly built and plan the loop. Our build features both CPU and GPU blocks, so we're going for a full loop to include a 360mm radiator. Once they're installed, we can move on.

2 MAKE A PLAN

It's time to start measuring and planning, ready for taking on our 3D modeling challenge. With our Dark Base 900 now

filling up with parts, we can really see this build coming to life. The theme is black, with white coolant, so the reservoirs should really stand out.

» From the planning stage, the PSU basement area offers somewhere to mount our pump, keeping it hidden and preventing it being a distraction. Little things, like where to hide a pump, can make or break how the system is configured, and its final look.

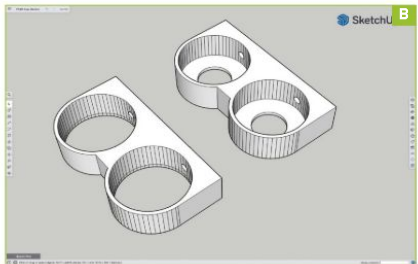
» The reservoirs have single port end caps; they are slightly modified from an original Alphacool reservoir, by replacing the bulky multiport bottom ends with simple top caps. It makes them slightly shorter and is yet another great way to tinker with the final look.

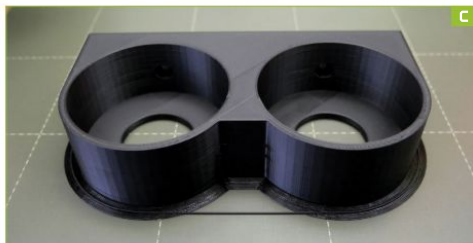
» Looking behind the reservoirs [Image A], you can see we've removed the top and bottom single drive bay slot covers. These are where we'll mount the reservoir holders, the bottom mount being enclosed, with the top support being an open, wraparound design. The mounts also need to be lifted off the PSU shroud, to allow fittings to attach underneath and connect to the pump.

3 MODEL BEHAVIOR

Down to the complex part: modeling. SketchUp is our choice of software. It's straightforward and reasonably intuitive, meaning it shouldn't be too daunting if you've never used a CAD program before.

» Our 3D printed parts will hold two 50mm-diameter cylinder reservoirs, so that's the first measurement we





need for the openings, with an extra 1mm for clearance. Now we can move to the size of the hard drive slot covers. As the top and bottom parts will be separated, we don't need to take too much into account in terms of vertical placement. We know the cylinders come above the last single slot cover and we'll mount the top bracket in an appropriate place.

» With the slot covers being 115mm wide, our holders can be around the same width; in terms of depth, they don't obstruct the front-mounted 360mm radiator, so we're not constrained there either. With a few more calculations and using the built-in tools, we can draw up our parts.

» Work slowly, and double-check all measurements; so mistakes can be corrected and won't cost you print time. Our holders include recessed holes for mounting with M3 screws and nuts; be sure to include options for how to mount the parts. Once done, we can export them and take them to our printer [Image B].

4 PREPARE TO PRINT

PLA (polylactic acid) is a great choice of material to print with—this system won't be subjected to heat levels beyond its capabilities, and given the design of our parts, PLA should be more than strong enough to cope with the small amount of weight bearing it has to endure.

» We set up the print in Prusa Slicer, going with 0.2mm layer height, at 65 C on the bed, with an infill of 20 percent. These numbers will vary for your own printer, though, so go with what you know works best. Our print time was calculated at around five hours, so let's print!

5 FIT AND DRILL

With our parts printed [Image C], we can fit M3 nuts to the insides of the mounts; we will drill through the drive bay slot covers and attach the brackets using M3 bolts. A tight fit allows them to sit in place firmly, making our job of mounting later a lot easier.

» Now it's time to decide if the printed parts need painting. Ours don't look too bad, so we'll leave them, to give you an idea of how good they can look without more prep and paint. Depending on



your build's theme, you could paint them in a contrasting color, or try to blend them into the background.

» We can now fit everything together using a small drill bit to create the mounting locations for our M3 bolts.

» As you can see [Image D], the bottom bracket has openings to allow our fittings to connect, while the top mount fits around the cylinders, to hold them in place. Position each bracket over the slot cover or surface, and mark up for drilling. Then drill and attach to the panel. Once done, we can move on to completing the system, ready for filling and final checks.

6 TEST YOUR SYSTEM

Finishing touches include pressure testing and filling the loop. Connecting reservoirs can be tricky with a custom solution. Draw what you intend to build, take measurements, and make sure it will all fit. Also, ensure you have somewhere easily accessible to fill and drain the system. Mounting the radiator with the ports to the bottom not only helps with connecting to our pump, but also lets us fill the system from above using the drain port at the other end of the radiator.

» As we are finishing the system, take care with the cable combs, neaten everything up, and make sure your



cable management behind the back panel is good. Check for leaks and run the system for 24 hours to ensure that everything works as it should [Image E]. A custom rig is only as good as its creator; the time put into building it should be a rewarding process. Don't look back and wish you had done this or that; you should be making any changes or adjustments now.

7 FINAL THOUGHTS

This is what we call the baby steps: starting to put your own signature on a build. Once you feel comfortable producing small mods like this, you can develop your skills and move on to bigger and more complex ideas. Don't just do something for the sake of it, though; it needs to bring something new to the party, be part of a theme, or solve a specific problem.

» This res holder can be as simple or as complex as you want. Turn it into a full sleeve, maybe, with an intricate design exposing the coolant behind it; change the shape of the mount; add more cylinders in a curve—the list goes on. Once the basics are there, the ideas flow and more options are viable. All of a sudden, these mods don't seem as scary as they used to be. ☺

Machine of the Month: Atari 800 Series (1979)

YOU'LL NEED THIS

ALTIRRA

For more casual users: www.virtualdub.org/altirra.html.

ATARI800

Advanced users: <https://atari800.github.io/download.html>.

THE ATARI 800 series is often overlooked in retro computing, but this machine genuinely put the wind up companies such as Apple and Commodore, establishing an architecture that sold millions of units with a long production run.

On its release, the 800 was ahead of its time and one of the most powerful computers around, bringing innovations such as specialized coprocessors to ease CPU load.

Being an Atari machine, the 800 family features the classic Atari arcade library, but is also an essential experience for fans of '80s micros.

So, let's take a brief history lesson before exploring how you can emulate the 800 line yourself at home. —JOHN KNIGHT

1 DEVELOPMENT AND LAUNCH

The 800 series was born when Atari realized its console hardware could be expanded upon with a keyboard, and other kinds of I/O, to make a television-based micro. The Atari 800 would be the foundation upon which other models could follow, using the same basic chipsets and architecture.

» Launching in November 1979, Atari's initial lineup consisted of two models: the fully featured 800 for \$1,000, and the stripped-down budget model 400 for \$550. The 800 had two cartridge ports, four expansion slots, and a proper keyboard; the 400 had one cartridge port, two expansion slots, and an inexpensive childproof membrane keyboard.

» Both machines ran a highly clocked MOS 6502 @ 1.79MHz, with 8KB of RAM. The 400 could be expanded to 16KB, while the 800 could take up to 48KB. The 400 would later sell with 16KB and the 800 would sell with its maximum 48KB. The 400 sold twice as many units as its big brother.

» Color handling is the Atari's showpiece. Often referred to as 128 colors, the Atari featured "16 colors each with 8 intensities".

» After several years of Atari leading the market, the aggressively priced Commodore 64 forced Atari to adapt the 800 series with lines like the XL series. These could use more RAM, thanks to new variants of the 6502 CPU, and cut features rarely used on the 800.

» Atari had a false start with its poorly received 1200XL, which was too expensive and not entirely backward compatible. However, the company found new success with the 800XL, a smaller, cost-reduced, simplified version of the 800, with 64KB of RAM. It was paired with its 600XL little brother, which shipped with 16KB of RAM, expandable to 64KB. The 800XL was especially popular in Europe.

2 GAMING

The 800's gaming scene generally sits in two categories: earlier games, which were largely ports from Atari arcades, and later games from the '80s microcomputer scene.

» The 800's arcade ports are usually better than on the 2600 console, with more detailed graphics and additional gameplay elements. As for 8-bit micro gaming, the Atari probably sits somewhere between an Amstrad CPC and a Commodore 64.

» Unlike many rivals, the Atari has proper hardware scrolling. While the Atari's POKEY sound chip isn't as good as Commodore's SID chip, it is respectable nonetheless. And among the main 8-bit micros, the Atari probably has the fastest CPU. But when it comes to colors, the Atari destroys the competition, with abilities

more like a 16-bit machine. On the downside, the Atari has weak sprite handling and a low resolution, with blockiness like an Amstrad on a bad day. And because of developers supporting machines with less RAM, Atari ports often cut features available on rivals.

» Nevertheless, numerous Atari ports were superior to rival machines and there are plenty of exclusive titles worth trying. To pick some gaming highlights, *Star Raiders* (1979) provided early 3D space flight and was the Atari's "killer app." *Rescue on Fractalus!* (1984) is an early experiment in first-person fractal-generated landscapes. *Alley Cat* (1984) is much better than its PC equivalent, and *Ballblazer* (1984) is better than on all other machines, 8 or 16-bit.

3 LEGACY

As the 1980s dragged on, software support was becoming increasingly scarce. Despite this, Atari kept the 800 series going with refreshes, such as the XE series, which was styled to look like a 16-bit Atari ST and could take 128KB of RAM, and the XE Game System console, which came with a lightgun.

» Over time, Atari sales shifted from America to Europe, and eventually to Eastern Europe. Atari finally ended support for the 800 series in 1992, having sold between 4.5 and 5 million units.



» It might be blocky but *Alternate Reality: The City* (1985) shows off the Atari's superior color system over other 8-bit micros.

© DATASOFT



» The original 800 was a large, imposing machine, designed to look like a typewriter, and featured four [yes, four!] joystick ports.

4 EMULATION
Of the numerous emulators available, we like Altirra and Atari800. Altirra is much more user-friendly, while Atari800 has a retro-style interface that veterans may love. Atari800 has versions for Windows and Linux, but Altirra only has a Windows version, though it works well through Wine.

» While both emulators now have open-source replacement system ROMs, proper system ROMs will give the best compatibility. Luckily, legally available ROMs are available through another emulator, XFormer. We wouldn't recommend XFormer to casual users, but we can at least use its binaries. The Atari800 download page has a link to an older version—just unzip the package and we will point to it in a moment.

» A final tip: If you get stuck at a game's title screen, try pressing F2, which is the standard Atari key for "Start," while F3 is "Select."

S ALTIRRA: BEGINNERS
The Altirra homepage (www.virtualdub.org/altirra.html) provides a ZIP file with Windows binaries. Download and extract the file, and in the Altirra program folder will be two executables: Altirra.exe for 32-bit systems and Altirra64.exe for 64-bit systems.

» Once opened, Altirra runs a First Time Setup wizard. Click "Next" and in the "Setup firmware" section is a "Scan folder for firmware images" button. Skip this if you want to try the replacement ROMs; otherwise click it and choose the folder where XFormer is extracted, then proceed to the next section.

» In the "Select system" section, keep the default choice of "XL/XE Home Computer" and click "Next." The following screen has a choice of NTSC or PAL. This can be changed later on, but for now choose NTSC if you plan on mostly playing US games, or PAL if you're more likely to play European titles. Keep clicking "Next" until you reach the "Finish" button.

» To get started running software, from the main menu click "File → Boot Image," and choose your file.

» Unfortunately, no joystick devices are enabled by default—not even keyboard-based joystick emulation.

» Enable a joystick by clicking "Input → Port 1," and then selecting a device from the given list. The first choice, "Arrow Keys → Joystick (port1)," uses the arrow keys for movement and Left Ctrl for fire.

6 ATARI800: ADVANCED
Make sure you use the newest version of Atari800, which has cleaner code and an open source replacement ROM. If you're stuck using an older version, externally sourced system ROMs are needed to play anything at all.

» At the website's download page (<https://atari800.github.io/download.html>), follow the Atari800 GitHub link, which has downloads for Windows, .deb packages for Linux, plus source code.

» For the Windows version, download the win32 ZIP file and extract the contents into a new folder. Inside this folder is the atari800.exe executable.

» For Linux users, if you can't install the .deb packages, a Snap is available with an older version. Once installed, Atari800 should be in your system menu, or can be run with this command:

```
$ atari800
```

» Once inside the emulator, press F1 to access the system menu. Atari800 will be running in a tiny window, so first open "Display Settings → Video mode settings" to increase the resolution or enable full-screen.

» If you want to use the XFormer system binaries, from the main menu choose "Emulator Configuration → System ROM settings → Find ROM images in a directory." Now, from the file browser that appears, navigate to the extracted XFormer folder, and once inside, press Space.

» By default, Atari800 has joystick 1 set to the number pad, with Right Ctrl as fire.

SPECIFICATIONS

ATARI 800 SERIES (1979)

CPU:	MOS Technology 6502 @ 1.79MHz
RAM:	8KB to 48KB
Launch price:	\$1,000
Graphics:	16 colors x 8 intensities @ 160x96, monochrome @ 320x192
Sound:	POKEY I/O chip, 4x oscillators with noise mixing, or 2x AM digital
Storage:	Cartridge, cassette, 5.25-inch floppy
OS:	Atari BASIC, Atari DOS
Released:	November 1979
Production:	1979–1983
Worldwide sales:	4.5–5 million



» Yump! (2007) is a modern classic from the Atari 800 community, which is still making games and demos for it.

LAB NOTES

CHRISTIAN GUYTON, STAFF WRITER



Glutton for Punishment

What did I get up to in my time off?

IF YOU'VE EVER had chemotherapy, you have my undying respect. Both physically and mentally, it's a roller coaster that I wish I wasn't tall enough to ride. I spent a lot of time cycling between the bed and the couch, struggling to eat or sleep. Distraction from the pain and nausea was often the best strategy, and the whole experience has given me a new appreciation for PC games as a form of escapism.

I moved my PC into the living room and set up a PS4 controller link so I could play from the relative comfort of the couch. I tried to delve into some narrative-focused indie games, but found they couldn't hold my attention. It made sense; I struggled to watch TV or movies, always thinking instead about the sickness in my stomach or when my next treatment session would be.

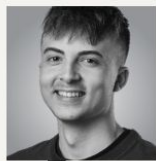
So I tried a different approach: hardcore games. *Risk of Rain 2* was my first entry.

a punishing roguelike with super-fast combat. I was hooked; this was a game that demanded my full attention. On the later stages, stopping for even a moment meant certain death.

Next was *Darkest Dungeon*, a tough-as-nails RPG that is more than willing to punish the slightest slip.

The pace was slower, but I found myself worrying more about my party's insanity meters than my own mental health. Finally, I jumped into *Dead Cells*, another roguelike, which rewards speed and aggression.

Games helped me through. So did the amazing support of the *Maximum PC* team.



SAM LEWIS

Staff Writer

My retrofit Apple CarPlay system is working as well as I wanted it to. I thought by now I would have found a way to charge the tablet while driving, but I haven't yet. With a 4.5-hour drive to the photo studio the other day, the battery just about lasted there and back, with a small portable charger being used to juice it up a little between

journeys. I want a more fixed solution—a USB-C hub with pass-through charging would be ideal, but I keep seeing negative reviews on Amazon. On to bigger things: My first PC build is now complete, and although it consisted of relentless shouting and near-brain-smashing anger, I got there in the end, and look forward to future builds.



KRIS BUTTERILL

Contributor

Even now, *Modern Warfare 2* is a great multiplayer game. Yet it was from an era with a simplistic level-up system: You earned XP for kills, job done. It was fun to clock up kills, safe in the knowledge that I only needed another 400 points to open up that new weapon I'd wanted for ever. Challenges were cool, and knowing I'd mastered

everything on offer was a journey to fulfillment—and, mostly, a heck of an exciting one. Nowadays, it's XP for this, level up for that, golden skins, and outfit unlocks. Even menu structures were more intuitive back then. I miss the simpler days, when you knew what was going on in a game like *COD*. Is it just me? Am I getting old? Maybe.

Editor's Pick: Asuswrt-Merlin Project

Wizardry for your router



THIS LAST MONTH, I've been through ISP hell. I genuinely believe grabbing a bag of wasps, shaking it violently, then shoving my bald head inside

would have been a more productive pursuit than the amount of time I wasted trying to get a coherent response from my provider's customer support department.

I decided to switch back in February. I had a 145Mb/s download speed and around 17Mb/s upload with my old provider. There was no nonsense or bluster, and not a whiff of a problem. The contract was due to end, however, so I decided to swap to a similar package with another company, as it was 50 percent cheaper. I knew it was a risk, the company didn't get very good reviews, and I was warned against jumping ship.

Overnight, my speeds dropped from a consistent 145Mb/s to anywhere between 60 and 100. The ISP blamed it on everything under the sun. From my phone line, to problems with the infrastructure, to the wiring in my house (despite nothing having changed), before it finally settled on my router being the cause of the problem. I was told by a service rep that I should be using their equipment, and that it was far better than the gear I had.

You know, better than the Asus RT-AX88U I use, a fully capable Wi-Fi 6 beast of a thing. I've spoken before about the problems I had streaming TV over it, and I'm glad to report those issues were resolved with a firmware update. Since then, it's been golden—until this rather large hiccup with the new ISP.

Customer services condescendingly told me that I needed to perform a factory reset of my router, which I refused. The main reason is I have over 30 smart devices, which are a nightmare to reconnect. Some



even require me to hop on a ladder outside my house, remove a spider-infested faceplate (I'm mildly arachnophobic), and hit a reset button. Obviously, I was less than enthusiastic.

Last time I spoke of my troubles with the RT-AX88U, a few of you recommended Asuswrt-Merlin, as it's better than the stock firmware on most Asus routers. I was reluctant, again due to not wanting to perform a hard reset, but as everything else had failed, I decided to give it a go.

Amazingly, it acts like a firmware update, rather than a fresh install. It keeps all your settings, and adds a ton of fixes, optimizations, and nerdy stat monitoring, which I'm a sucker for. In fact, a lot of the features have been added to the standard Asuswrt firmware, and it's updated regularly to patch any security holes.

Sadly, it didn't remedy my performance problems with the ISP, but I've noticed temperatures are lower across the board, which is always a plus, and I'm still exploring its full depths. But so far, so good. If you're having problems with your networking, and have an Asus router, it might be worth seeing if Merlin can help. I'm still looking to move to a new Wi-Fi 6E router once they're available, but for the time being, Merlin seems to be working a treat.

As for the ISP? I managed to wrangle my way out of the contract early, free of charge, and have now gone back to my previous provider, tail tucked between my legs. You live and learn, I guess. —**ZS**
\$free/donation, www.asuswrt-merlin.net

Reviewed...

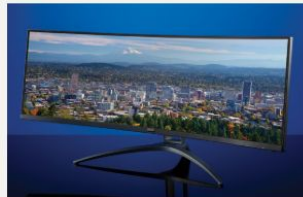


72 AMD Radeon RX 6800

74 Nvidia GeForce RTX 3060 12GB



76 Corsair One a200



78 AOC Agon AG493UCX

80 Oculus Quest 2

82 Lian Li PC-Q11-Dynamic Mini

85 Topping E30 & L30

87 AVerMedia PW315

89 Picttek PC305



90 Nier Replicant ver.1.22474487139

92 Spotify vs. Tidal



The RX 6800 is a potent competitor against Nvidia's RTX 3070.

AMD Radeon RX 6800

All the VRAM, plenty of cores

AMD'S RADEON RX 6800 launched last year, but in the hustle and bustle, we never took the time to give it a proper review. The higher-spec RX 6800 XT stole the limelight, with a decent jump in performance for a relatively modest increase in price. Of course, there's nothing modest about current street prices, where finding any of the Navi 21-based cards for under a grand seems like a great deal.

The main changes relative to the XT model come in the form of cores and clocks. Instead of 72 CUs, you get 60, and instead of a 2,250MHz Game Clock, you get 2,105MHz; the 6800 also has 96 ROPs (Render Outputs), compared to 128 on the XT. It still provides the full 128MB Infinity Cache and 16GB of GDDR6 memory, though, so you're not losing anything in those departments. In practice, that makes the plain Jane vanilla RX 6800 about 12 percent slower than the XT, and it costs—theoretically—11 percent less.

Where things get interesting is the competition. AMD went big on memory capacity, which makes the 8GB of Nvidia's RTX 3070 and 3060 Ti seem pathetic by comparison. There aren't many games

where it makes a major difference, yet, though AMD has worked with several game developers to push the boundaries on VRAM. *Assassin's Creed Valhalla*, *Dirt 5*, *Godfall*, and the new *Resident Evil Village*, for example, can all use about 12GB of VRAM at maxed out settings. Not surprisingly, the RX 6800 looks particularly potent in such games—helped by some AMD-targeted DX12 optimizations as well, no doubt.

Across our suite of gaming tests, the RX 6800 pummeled the RTX 3070, delivering a 15 percent overall performance lead. But as we've noted before, the number of games that use ray tracing or DLSS (or both) continues to grow. We selected 10 DirectX Raytracing (DXR) games for additional testing, six with DLSS 2.0 support. At native resolution (no DLSS), the 3070 turned the tables and beat the RX 6800 by 15 percent. With DLSS Quality mode, which delivers image fidelity on par with native rendering in most cases, the 3070 more than doubled the frame rates of the 6800.

On the whole, we'd give AMD's card the edge in pure performance—there are far more rasterization games than ray-

tracing games. Plus, we think the 16GB of VRAM will prove beneficial in the coming years, though if a rumored RTX 3070 Ti shows up with 16GB at a similar price, things could change.

If you're interested in cryptocurrency mining on the side, the RX 6800 is just as fast for Ethereum hashing as the RX 6800 XT and 6900 XT—memory bandwidth being the limiting factor. It's also slightly faster than the RTX 3070 as well (64MH/s after tuning, compared to 61MH/s), thanks to the higher memory clocks. However, availability for AMD's Navi 21 cards is unfortunately even worse than the RTX 3070.

The RTX 3070 shows up on Valve's Steam Hardware Survey as the most popular Ampere card, with 1.42 percent of all DirectX 12 capable surveyed PCs. That's more than AMD's RX 5700 XT, the most popular previous-gen GPU, at 1.04 percent. The RX 6000 series doesn't even crack 0.3 percent of the market—assuming Valve's stats are accurate.

If you're still not particularly worried about ray tracing in games, and you can find an RX 6800 in stock at a reasonable price, it's a great option. AMD's FidelityFX Super Resolution (FSR) could make it even better, giving it a DLSS alternative. But we wouldn't recommend paying \$650 for such a card, never mind the \$1,200-plus they currently go for on eBay. Given time, you could potentially get an RTX 3080 Ti for that price. —JARRED WALTON

AMD Radeon RX 6800

■ VANILLA BEAN Plenty of RAM and cache; strong 1440p performance.

■ IMITATION VANILLA FSR still MIA; weaker RT performance; good luck finding one.

\$650, www.amd.com

BENCHMARKS

	AMD Radeon RX 6800	AMD Radeon RX 6800 XT	Nvidia GeForce RTX 3070 FE
Eight-Game Average (fps)	108/65	124/76	93/57
Assassin's Creed Valhalla (fps)	93/54	108/63	71/44
Borderlands 3 (fps)	112/61	133/73	86/48
Dirt 5 (fps)	114/74	139/90	98/66
The Division 2 (fps)	109/57	127/67	100/53
Forza Horizon 4 (fps)	202/148	206/168	175/125
Horizon Zero Dawn (fps)	119/67	136/76	106/61
Metro Exodus (fps)	85/54	99/63	79/50
Red Dead Redemption 2 (fps)	96/63	108/72	81/55
Watch Dogs Legion (fps)	76/44	91/53	73/43

Best scores are in bold. Our test bed consists of a Core i9-9900K, MSI MEG Z390 ACE, 2x 16GB DDR4-3200 CL16, 2TB XPG 8200 Pro M.2 SSD, and Seasonic Focus G 850W. Scores show average fps at 1440p/4K Ultra.

SPECIFICATIONS

GPU/Architecture	Navi 21
Lithography	TSMC N7
Boost Clock	2,105MHz
Memory	16GB GDDR6X
GPU Cores	3,840
TFLOPS FP32	16.2
TDP	250W
Display Connectors	2x DisplayPort 1.4 with DSC, 1x HDMI 2.1 VRR and FRL, 1x USB Type C

Nvidia GeForce RTX 3060 12GB

More memory, less bandwidth and compute

IMAGINE FOR A MOMENT that there's such a thing as a GPU that's about 20 percent faster than its predecessor and costs less money. That sounds like a good product. Sadly, only one of those things exists right now.

On paper, Nvidia's RTX 3060 continues the well-trodden path of releasing smaller and less costly GPUs that also trim performance, at a theoretically lower price. Unfortunately, cryptocurrency mining, the pandemic, and global shortages of chip manufacturing and substrates make the latest addition feel every bit as much vaporware as the other Nvidia Ampere and AMD RDNA2 GPUs launched in the past nine months.

But these GPUs do actually exist. We have tested every one of them, and you can even find them on places like eBay. It's just that most of the cards are marked up to two or three times the "official" MSRPs. Unfortunately, we don't anticipate any modern graphics card will sell for its MSRP any time this year. Let's just assume you could choose between the cards, though, rather than just taking whatever GPU you manage to find in stock. How does the RTX 3060 stack up?

To date, this is the most compact and affordable RTX card Nvidia has

created. The GA106 die size is 276mm², about 38 percent smaller than the TU106 that powered the RTX 2060. It's also nearly double the theoretical compute, with twice as much GDDR6 memory. In our testing, the 3060 ends up about 20–30 percent faster than the 2060, depending on the game and settings. But let's not get too excited, as the old RX 5700 XT still typically performs better than the 3060 in traditional (i.e., not ray traced) games.

We also ran the cards through an extended suite of ray-tracing benchmarks, with DLSS 2.0 quality mode enabled. The RTX 3060 strutted its stuff, beating the RTX 2060 by 35 percent on average at 1080p and 40 percent at 1440p. Against AMD's lowest-tier RX 6000 card, the RX 6700 XT, ray-tracing performance at native resolution was a tie, but add DLSS 2.0 to the picture and the 3060 was up to twice as fast.

And DLSS isn't just for ray-tracing games. More than a dozen titles have DLSS 2.0 support and don't use ray tracing, such as *Death Stranding* and *Call of Duty: Warzone*. Plus, all the games with ray tracing and DLSS 2.0 can still use DLSS even if RT is off. Comparing DLSS to native resolution isn't an apples-to-apples matchup, but if you're

looking at DLSS Quality mode versus native resolution, it's difficult to spot any differences—unless you look at frame rates, in which case, DLSS tends to be 30–50 percent faster.

AMD is still working on its alternative to DLSS, called FidelityFX Super Resolution. Actual details and screenshots are lacking, however, and Nvidia has had more than a two-year head start. With Unreal Engine and Unity Engine both supporting DLSS 2.0, there will likely be even more games taking advantage of Nvidia's tech. Could FSR match DLSS in image quality and performance? Perhaps. It just needs to come reasonably close, but then we already have games that use temporal upscaling and it doesn't look nearly as good as DLSS 2.0.

The problem with availability remains, though. Nvidia even implemented anti-mining tech to make the cards less enticing to Ethereum miners, but then accidentally gave away the key to the lock with a dev driver. It's working on updated models that will fully reinstate the lock, and the tech will likely extend to other Nvidia Ampere GPUs in the future. Even before the anti-mining lock was circumvented, however, the cards were selling for \$800 or more online.

If at some point over the coming months the RTX 3060 starts selling for \$350 or less, it will be a great option. But until and unless that happens, it's all hype and lacking in substance. At this rate, we could see the next-generation RTX 40-series GPUs launch before supply of the RTX 30-series reaches the desired level. —JARRED WALTON

VERDICT



Nvidia GeForce RTX 3060 12GB

■ AFFORDABLE 12GB; good 1080p performance;

DLSS 2.0 is great.

■ HIDDEN FEES Modest performance; the MSRP is a lie; sold out.

\$350, www.nvidia.com

BENCHMARKS

	Nvidia GeForce RTX 3060 12GB	Nvidia GeForce RTX 3060 Ti FE	Nvidia GeForce RTX 2060 FE
Eight-Game Average (fps)	63/37	81/49	51/29
Assassin's Creed Valhalla (fps)	50/30	61/39	43/25
Borderlands 3 (fps)	55/31	74/42	46/24
Dirt 5 (fps)	63/39	86/56	56/35
The Division 2 (fps)	65/34	88/45	53/27
Forza Horizon 4 (fps)	123/81	157/108	100/66
Horizon Zero Dawn (fps)	76/42	89/50	63/35
Metro Exodus (fps)	52/32	69/44	43/26
Red Dead Redemption 2 (fps)	57/37	72/49	43/29
Watch Dogs Legion (fps)	48/28	62/37	33/18

Best scores are in bold. Our test bed consists of an Intel Core i9-9900K, MSI MEG Z390 ACE, 2x 16GB DDR4-3200 CL16, 2TB XPG 8200 Pro M.2 SSD, and Seasonic Focus G 850W. Scores show average fps at 1440p/4K at Ultra.

SPECIFICATIONS

GPU/Architecture	GA106
Lithography	Samsung 8N
Boost Clock	1,777MHz
Memory	12GB GDDR6
GPU Cores	3,584
TFLOPS FP32	12.7
TDP	170W
Display Connectors	3x DisplayPort 1.4a, 1x HDMI 2.1



EVGA sent us an RTX 3060 running reference clocks, but most models will come factory overclocked.

Corsair One a200

Slim, sleek, and brimming with power

THE CORSAIR ONE has always impressed us. It follows a line of crazy, out-there ITX towers that have tickled our fancy over the years. From NZXT's H1 chassis to the tiny liquid-cooled Shift X we built, there's just something about packing as much power into as small a box as possible that really does get the tech juices flowing. So, when we got a chance to take an in-depth look at the latest updated variant, we jumped at the opportunity.

The Corsair One was, by design, a unique piece of engineering when it first debuted back in 2017, and it still is, in a lot of ways. Back then, a single 140mm fan placed at the top cooled the entire system through negative pressure and some very clever engineering. The chassis was split down the middle—on one side you had your standard ITX motherboard, on the other a full-length GPU of some description. Both the processor and the GPU were cooled by 240mm radiators either side, but neither had any fans attached. Instead, that single 140mm fan pulled air through the chassis, then up out the top. It's clever, and worked well to keep the case both cool and quiet.

With the a200, the latest update to the seminal series, Corsair has packed in all the latest hardware you can get. In our sample, we have an AMD Ryzen 9 5900X 12-core processor, an Nvidia GeForce RTX 3080, 32GB of DDR4 @ 3,200MT/s, a 1TB Corsair Force MP600 PCIe SSD, and a 2TB HDD as a backup. All of that sits on an ASRock B550 Phantom Gaming ITX motherboard, and is powered by what is definitely one of our favorite small-form-

factor PSUs of all time, the Corsair SF750 80+ Platinum.

Under closer inspection, however, there have been a few changes to the overall design of the case over the years, but nothing immediately apparent. It's only when you get under the hood that you see the big shakeups, and it's all to do with that Nvidia card. To get inside, there's a small push button near the rear I/O—pop that in, and the top heatsink and attached fan pop out. Carefully unclip the fan cable from its extender, and you are witness to a bare steel chassis. Take the four screws securing the side panels out, and you can now carefully lift the panels up to reveal the internals.

HOT CHIPS

There are still twin 240mm radiators here, both featuring the older style H100 block design, but the big change is on the GPU side of things. As we know, the RTX 3080 is hot, real hot, particularly with its memory chips and VRM solutions. To counter that, Corsair has implemented two small fans that sit over those parts, drawing cool air in through the radiator to cool them, while the GPU itself is still cooled by that fat 240mm AIO through the power of negative pressure.

Now, that sounds like it shouldn't work, especially with a single 140mm fan, but it does, and it works well. In extended gaming periods, with 23°C ambient temps, the CPU barely rose above 88°C, while the GPU sat comfortably at 80°C for long periods without batting an eyelid. On top of that, it's remarkably quiet, too. You

can hear it, of course, but it's certainly not deafening or ungamely—heck, it even put our nine-fan-powered 4K gaming PC to shame, a system with a similar spec, yet far more cooling potential.

As for performance? Well, figures are exactly where you'd expect for the parts in question. Early PCIe 4.0 SSD speeds, decent single and multicore performance from the Ryzen 9 5900X, and the RTX 3080 just chews through games like it's not even trying. We'll let the benchmarks table do the talking for that.

Is it good value, though? Well, yes and no. Outright it costs \$3,800—that's a lot of money. You could technically build a similarly specced system for just \$2,621 (at recommended retail prices). If you could find the parts, of course. But it wouldn't be as small, as cool, as quiet, or as well engineered as this rig is. And, to be honest, that's the big sell. If you need a PC that checks all those boxes, without the hassle of having to tinker with it, and get it up and running on your own, this might be the perfect pick for you, assuming it stays in stock for longer than five minutes. —ZAK STOREY



Corsair One a200

■ VITRUVIAN MAN Extremely compact; quiet; powerful; impressive airflow; awesome build materials.

■ STICK MEN Pricey.

\$3,800, www.corsair.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	1,398	3,499 (150%)
CrystalDisk 0D32 Sequential Read (MB/s)	3,531	4,947 (40%)
CrystalDisk 0D32 Sequential Write (MB/s)	3,473	4,236 (22%)
Middle Earth: Shadow of War (fps)	78	82 (5%)
Total War: Warhammer II (fps)	75	75 (0%)
Shadow of the Tomb Raider (fps)	85	91 (7%)
Red Dead Redemption II (fps)	78	82 (5%)
Assassin's Creed Valhalla (fps)	54	55 (2%)

Our zero point consists of an Intel Core i5-10600K, 16GB DDR4 @ 3600, an MSI GeForce RTX 3080 10GB SUPRIM X, and a 1TB Samsung 980 Pro (operating at PCIe 3.0). All tests were performed at 4K on the highest graphical profile available.

SPECIFICATIONS

Processor	AMD Ryzen 9 5900X
Graphics	Nvidia GeForce RTX 3080
RAM	32GB (2x 16GB) Corsair Vengeance LPX DDR4 @ 3200
Motherboard	ASRock Phantom Gaming B550 ITX WiFi
Storage	1TB Corsair Force MP600 M.2 PCIe 4.0 SSD (boot), 2TB HDD
Cooling Solution	Twin 240mm AIOs, 1x 140mm ML fan, 2x GPU cooling fans
PSU	Corsair SF750W modular PSU
Case	Corsair One
Warranty	Two years



It may not
have changed
much, but this is an
engineering marvel.

It's big, but is it beautiful?

It's not the first monitor based on a huge 32:9 aspect LCD panel, of course, but such is the sheer scale of the thing and so crazily wide the proportions, it's still an almost shocking sight sitting

That native resolution basically means you're getting a pair of conventional

Not that DPI is necessarily a major consideration for the AG493UCX's core remit of gaming. Indeed, there are more than enough pixels to keep your graphics card busy. A total of 7.3 million is up there with a full 4K panel, so you'll need a very

powerful GPU to drive this beast properly in demanding games.

That consideration aside, issues such as response and sheer visual punch are more critical. With that in mind, AOC has included three user-configurable levels of pixel-accelerating overdrive. In truth, they don't have a huge impact, but at least the most aggressive setting isn't rendered irrelevant by introducing lots of ugly overshoot and inverse ghosting.

Anyway, overall pixel response is decent, but not up there with the latest, fastest IPS panels. That's not a surprise, given this is a VA, not IPS, monitor, with a GtG response rating of 4ms, while the best IPS screens are now quoted at 1ms. Such metrics aren't terribly reliable, but that claimed performance gap is at least indicative of a slight shortfall in speed versus the very best LCD monitors.

More impressive and once again a consequence of the VA panel tech is contrast performance. Combined with the 550-nit peak brightness, it makes

for an above average HDR experience for a DisplayHDR 400 screen with no local dimming support. Want an example? *Cyberpunk 2077* running in HDR mode with ray tracing enabled absolutely, positively zings. Add in the huge scale of the panel, plus the wrap-around effect of the panel curve, not to mention the 120Hz refresh, and you have an incredibly immersive gaming experience.

There are, inevitably, caveats. SDR content calibration in HDR mode is pretty terrible, introducing the need to switch back and forth between modes for a decent experience, depending on content type. Plus, the extreme 32:9 aspect doesn't suit some games. Indeed, some titles don't even support it.

All of which means the AOC AGON AG493UCX is an acquired taste, for both its core remit of gaming and general duties. It's not for everyone. But if you understand and can accept the limitations and quirks of this kind of screen, there's nothing else quite like it. —JEREMY LAIRD

VERDICT

8

AOC Agon AG493UCX

■ BIG IS BEAUTIFUL Huge, immersive panel; very bright

and punchy.

■ SO BIG IT'S BAD Fat pixel pitch; quite a lot of quirks to consider.

\$999, www.aoc.com

SPECIFICATIONS

Panel Type	VA
Resolution	5120x1440
Brightness	550cd/m ²
Contrast	3,000:1
Pixel Response	4ms
Color Coverage	90 percent Adobe RGB
Refresh Rate	120Hz
VESA	100 x 100mm
Inputs	2x DisplayPort 1.4, 2x HDMI 2.0, USB C with 65W charging



AOC's new 49-inch beast packs VA panel tech and runs at 120Hz.

Oculus Quest 2

Heralding the arrival of true consumer-ready VR gaming

OCULUS REALLY HAS established itself as the king of VR, in spite of its onerous Facebook ownership. With only minor quibbles, the Oculus Quest 2 is a tour de force of VR consumer technology, delivering an easy-to-set-up, affordable, slick, cutting-edge consumer-level VR experience, which works as a standalone unit or as a PC-powered VR headset. In short, it checks all the boxes.

Perhaps we should deal with those quibbles. Firstly, the headstrap is poor. The Quest 2 headset is quite heavy and the awkward-to-adjust soft strap doesn't distribute the weight very well. It's obviously a cost-cutting exercise, because Oculus does sell an Elite Strap

option. Secondly, a Facebook account is mandatory, which is an annoying and baffling move, especially considering Facebook's recent record on privacy and security. Less quibbles and more points to know, the built-in speakers are acceptable—not very loud, but clear and without distortion—and the controllers feel cheap, but are sturdy, and require just a single AA battery each.

Reviewed using the v28 firmware, the Quest 2 comes with wireless PC connectivity out of the box in the form of Oculus Air Link. Previously, PC link options consisted of using a compatible USB-C cable or the respected wireless-capable Virtual Desktop third-party



Simplistic styling belies a hard-to-fault VR performance.

app. The new wireless Air Link just works, and is every bit as good as Virtual Desktop, although it does lack its bells, whistles, and extended options.

REFRESHING NEWS

The v28 release also introduces a 120Hz refresh rate, alongside the 72Hz default, 80Hz, and 90Hz options. Be aware, though, that Oculus games have to directly support the new rates for it to work, which even with 90Hz, is a limited list. PC-based games automatically benefit, but there is a compromise: a reduction in recommended rendering resolution, from the marvelous 4128x2096 to 3712x1872 at 90Hz and 3104x1584 at

120Hz. The display is excellent, but we still think VR needs higher resolutions ultimately—however, given the state of current technology, the Quest 2 is delivering near the cutting edge. Colors are vibrant, contrast levels are good, and it works well with or without glasses on, thanks to a supplied shim.

The Guardian system is a revelation, with no silly lighthouses to worry about: Slap on the headset, draw a line on the ground—which creates a virtual babysitter zone—and you're ready to play. Stepping near the limits first highlights the boundary (it disappears during normal use) and then switches to the infrared view of the room. You

can double-tap the headset at any point to view the room or escape the vision of you being eaten. The Guardian even remembers rooms you've used it in and autoconfigures on new sessions, though this is a little hit and miss.

The twin controllers are excellent in use, with standard controls—front and side triggers, thumbstick, two buttons, and a system button—meaning you can get up and running with all games with little worry. They feel a bit cheap but are sturdy enough. Also worth noting is that they're Bluetooth, which is built into the Quest 2, unlike the HP Reverb G2.

The Quest 2 is clearly in constant development—regular updates mean there's a steady stream of improvements, bug fixes, and more, released on a seemingly monthly basis. Oculus is also good with support, offering quick responses to issues, while the wider community seems happy to help, too.

Technical ability aside, the Quest 2 is a genuinely fun peripheral to own. The ecosystem and community that's sprung up around it is vibrant, welcoming, and prolific. SideQuest is an outpouring of development fun and energy, and the official Oculus Store, while a little limited, offers slick commercial releases. It's certainly a truly next-gen immersive experience. And at this price point, the Quest 2 is an absolute steal. **—NEIL MOHR**

VERDICT
9

Oculus Quest 2

■ **VIRTUAL REIGN** Excellent display; easy to use; great connectivity; fantastic value.

■ **VIRTUAL RUIN** Windows only; PC cable is extra; rubbish headstrap.

\$299, www.oculus.com

SPECIFICATIONS

Display	Single fast-switch LCD, 1832x1920 per eye
Refresh	72Hz (default), 80Hz, 90Hz, 120Hz
Comms	Wi-Fi 6, 1x USB-C, Bluetooth 5.1
Tracking	Inside-out, 6DOF
Audio	Integrated, 3.5mm jack, integrated mic
CPU	Qualcomm Snapdragon XR2
Memory	6GB
Storage	64GB or 256GB
Lens Distance	Adjustable—three presets
Play Space	9ft square, stationary
Battery	2 to 3 hours
Size	7.5 x 4 x 5.2 inches, 1.1lb



Lian Li PC-011-Dynamic Mini

The prodigy has been downsized

AFTER THE SUCCESS of the 011-Dynamic, Lian Li is back with its little brother. The PC-011-Dynamic Mini brings a scaled-down version of the hugely popular case to the market. It's for those looking for something smaller, and it won't come as a surprise, given the popularity of the original 011-Dynamic, that the 011-Dynamic Mini has flown off the shelves.

Lian Li seems to have taken the "if it ain't broke, don't fix it" approach, and rightly so, keeping it simple and literally scaling down the original to create a wondrous little case. There are some differences—there's no ATX power supply support here; instead it relies on SFX units to help it lose some weight—but the overall look and feel of the Mini is still very Lian Li. Brushed aluminum, acrylic, and tempered glass adorn the front, side, and top of the case, with the familiar procedure of removing first the top and then the side panels needed for installing a system.

The I/O has moved from the front to the top of the chassis, and the diet has also included switching to a single microphone/headphone combo jack; these are subtle changes that don't really detract from the overall feel of the case. The feet have also shrunk, with smaller corner units instead of full-length boots, as seen on its older sibling. The dust filters are functional, but the implementation of the bottom one could be better. While the top and side filters are magnetic, the bottom filter is removed by using a handle that protrudes from under the glass side panel, distracting you from looking at what's important. It's a minor

bugbear, though, and certainly not a deal-breaker—if anything, it reminds you to clean your rig more often.

Despite its compact size, you get a plentiful amount of water-cooling support, with an included modular pump stand, plus space for a custom hard-line loop to be installed. Some planning is going to be needed, but you're bound to see an influx of custom water-based systems over the coming months built inside this chassis. Add in the availability of distro plates from EKWB and others, and once again, this is going to be an instant hit for clean-looking, compact systems with that bespoke aesthetic.

The rear of the case is modular, enabling you to choose the placement of mATX and Mini-ITX-based builds for top radiator mounting. It's a great little concept and it doesn't feel gimmicky—rather, it's functional, and a fantastic use of space. With three layouts available for ITX-based systems, the hardest part will be deciding what else to throw in here.

Lian Li does offer a vertical GPU mount option, too, replacing the rear modular PCIe panel with the bracket instead. It's an extra, though, sadly, and only runs PCIe Gen 3, but a Gen 4 cable will be coming at some point in the future. For ATX builds, there's an included motherboard tray extension bracket that bridges out over the cable pass-throughs—these are large and more than adequate for building in a case this size, with ample room behind for hiding away the extra cable clutter. Regarding storage, drive mounts are plentiful, and with the rise in popularity

of M.2-based systems, if you are going for more storage than this case can handle, you're looking at the wrong chassis. There are no fans included, however, so that's something else to consider, because it adds to the overall cost of a build.

The Lian Li PC-011-Dynamic Mini is a pleasure to build in, spacious, and there's nothing fussy or elaborate for either beginners or expert system builders. It's a truly functional case that does what it sets out to do, and does it really well. And heck, it's pretty. —KRIS BUTTERILL

VERDICT



Lian Li PC-011-Dynamic Mini

THREE-COURSE MEAL Creative; very functional; really great to build with.

CHILDREN'S PORTION Tiny box; requires thought process.

\$120, www.lian-li.com

SPECIFICATIONS

Motherboard Support	ATX, mATX, Mini-ITX
2.5/3.5-Inch Support	2x/2x or 4x 2.5
Max Radiator Support	Top: 360mm; Side: 280mm; Bottom: 360mm
Fan Support	Top: 3x 120/2x 140; Side: 2x 120/140; Bottom: 3x 120/2x 140; Rear: 1x 120
Dimensions	16.5 x 10.5 x 15 inches
Graphics Card Clearance	15.5 inches
CPU Cooler Clearance	6.7 inches



Honey, I shrunk the case....

SUBSCRIBE TODAY

Find your next great read

On
iOS &
Android!



Subscribe today and get instant access on your iPad, iPhone, or Android device. Additional print options available.

<http://bit.ly/MaxPC21>

Topping E30 DAC & L30 Amp

Will this compact duo enter your audio setup?



WHAT WE HAVE here is not one but two audio products from Topping that pair together to really amp up your desktop audio experience. The E30 makes up the DAC part of this setup, while the L30 is the amp. Both products are visually similar and are of the same size and materials. For a two-piece setup, it makes perfect sense for these to stack on top of each other, and because of their matching designs, they make a pretty neat-looking addition to your desk.

One of the first things we noticed was the build quality of both the E30 and L30; with a black all-aluminum chassis, they feel great to the touch and provide peace of mind that these are solid, well-made products. Because both devices are fitted with rubber feet, they won't be sliding around—vital when stacking the two on top of each other. They also both have a glass front, which is admittedly a magnet for the odd grubby fingerprint here and there, but it gives the pair a truly premium look and feel.

The DAC features three input options: USB, optical, and coaxial, making the E30 pretty versatile. On the front of the DAC is a screen indicating a decibel reading in orange digital format. There is a touch-sensitive button that controls the power and enables you to select which input you want. Both products require power; the DAC can be USB-powered, but remember that if you're pairing this with your PC, it will inevitably take up two USB-A ports, one for charging and the other for the input (although you could go via the TOSLINK optical connector instead). Located on the back are the left and right channel outputs to the amp, and there is also a remote control, which oddly seems to be repurposed, as four of its buttons do nothing. That said, it does what it aims to do, and helps when you're not physically close to your setup.

The L30 is where you'll find all the physical controls for the setup. On

the left you have the output mode switch, next to that you have a gain switch, then a 6.35mm headphone output jack, and finally the volume knob. Also on the front is a tiny white LED power indicator, and while it would have been nice for this to be a little more obvious for its purpose, it does the job. Luckily, in the box you also get a 3.5mm adapter, so you can plug in more typical headsets.

JACKS OF ALL TRADES

On the back of the L30, you have left and right input jacks for connecting this up to the DAC, and left and right output jacks. These are to pass the signal through to any other active speakers or another integrated amp. To do this, flick the switch on the left of the L30 to "PRE." It's worth noting that if this is active, you can't have both outputs working at the same time. Also on the back is the power input, which leads us to a gripe with this setup. The power brick for the L30 is pretty darn big and heavy; if you're like us, and care about cable management, this will be a burden for your setup. You could have problems fitting it in tight spaces, and the cable is short, so the power brick can never be too far away from the amp.

With both of these products working in unison, the overall audio performance is vastly improved. The detail that these two devices release to your ears is exactly what you'd expect a DAC and amp to give you, and more. Clarity is the first thing you'll notice, hearing elements of songs that may have previously been drowned out. The sound is full and rich, making your favorite songs even more glorious. It almost feels as though you were lied to before using this setup to enjoy your music. Like most people who

have used similar products, you won't want to go back. With the DAC containing the AK4493 chip, which is a newer generation of AKM's premium AK4490, it can produce and upscale older audio files brilliantly. Paired with a Tidal Master account and a pair of planar magnetic headphones from Audeze, we managed to get incredible sound from this DAC/amp combo. If Topping could tidy up the smaller issues, like the chunky power brick and cheap remote, this would be a perfect all-around DAC/amp to propel you into the audiophile realm. —SAM LEWIS

VERDICT
9

Topping E30 & L30
PERFECT HARMONY Premium build quality; detailed and wide sound stage; diverse compatibility; great gateway into DAC/amps.
CHAOTIC DISCORD Large, heavy power brick; cheap remote; fingerprint magnet.
E30: \$128, L30: \$128, www.tpdz.net

SPECIFICATIONS	
Audio Quality	141dB DNR
DAC	32-bit/768kHz DSD512
Amp Output Impedance	<0.1 ohms
Features	Hi-res audio, NFCA modules, three-step gain settings, Velvet Sound Verita AK4493 DAC chip, Cirrus Logic CS8416 receiver, XMOS XU208
Connectivity	6.35mm jack output, RCA input/output, USB input, coaxial input, optical input
Dimensions	1.3 x 3.9 x 4.9 inches each
Weight	E30: 0.5lb, L30: 0.7lb

EXPLORE THE BEST LINUX & OPEN SOURCE SOFTWARE

From the best distros to system security, utilities and fun applications,
we've rounded up everything you could ever need



Ordering is easy. Go online at:

www.magazinesdirect.com

Or get it from selected supermarkets, newsagents, or bookstores

AVerMedia PW315

For both work and streaming?

SINCE ITS HUMBLE beginnings in the early '90s, Taiwanese company AVerMedia has been pushing the envelope when it comes to innovation in communication and entertainment peripherals. Webcams are one of the company's specialties, so with its PW315 sitting in the budget end of professional webcams, how does this model perform in a world where videoconferencing is skyrocketing?

The design of the camera follows a more traditional approach than the last webcam we featured, the Razer Kiyo Pro, but there are some benefits to this. Its smaller, more lightweight characteristics mean it puts less strain on your monitor, it's easy to take with you, and it takes up less room above or below your screen. The PW315 doesn't have the greatest of build qualities; the plastic is light and slightly cheap, with a faux-metal finish. The metal effect actually helps to make the webcam look more professional, and for the price, we can't complain too much.

The quality improves when it comes to the L-shaped mount, and although it has a large logo on the front, which many may not like, the mount feels very secure, keeping the webcam firmly in place when in use. It's essential for a webcam not to move around when recording, so it checks a box there. Under the L-mount is a typical tripod mount, which is great to see for alternative mounting options. It can swivel 360 degrees, too, so you could use this camera at all sorts of angles. Another big check for the PW315 is that it has an integrated privacy shutter. This slides across the lens when you want extra privacy. All cams should have this feature; there is no greater peace of mind than solid hardware blocking a camera (the tape method is way too messy). Next to the lens is a blue power indicator to let you know if and when the camera is in use. The final physical feature is the 4.9-foot USB-A 2.0 cable. The length is OK, but it's not detachable, so there's no option to upgrade to a longer cable.

Like most webcams, this model is plug-and-play, which we love—back to

simpler times! This is great for quick use, but if you want to delve deeper into the image and customize it to your taste, you absolutely can with the AVerMedia CamEngine software. By default, the image does seem washed out, so we recommend using the app to change the brightness and contrast; it comes with intuitive sliders. Some other features include gimmicky face effect tools, so you can make yourself look like a cat (or whatever takes your fancy). There is also a filter to adjust skin tone and smoothness, but we recommend leaving this alone, as it can look too artificial under poor lighting conditions. A good feature, however, is the AI framing tool; this zooms in on your face for you, and can follow you around if you move, to always keep you in the center of the shot—impressive for free software.

MUTE POINT

Regardless of the software, the image quality is solid and smooth. Capturing in 1080p at 60fps, we can't complain. However, as mentioned, the colors are a little muted straight out of the box. It also has an ultra-wide field of view, with 95-degree coverage; this fits lots into the shot and allows for some cropping post-recording. On the other hand, the flexibility of the camera lets it down a little, with no manual or even software focus. If you like to be in full control, you can't with this cam. There are also no options to film in anything other than 1080p at 60fps, so if you are after a smaller file size for streaming, this may be an issue that will involve further software to resolve.

When it comes to how you use this, whether it's in a professional manner

for videoconferencing or more casual use, such as communicating with pals or setting up a stream, the PW315 can handle most tasks. Its price sits toward the budget end, which becomes noticeable with its passable audio pickup from dual omnidirectional stereo microphones. Good communication is key, especially over the Internet, so having a decent mic is important. At least the camera performs well enough, thanks to its smooth frame rate. However, with limiting factors such as no manual focus, 4K sensor, or HDR, this webcam's image is a little tainted. —SAM LEWIS

VERDICT **7** **AVerMedia PW315**
■ **BUTTERY SMOOTH** 60fps
smooth recording; wide-angle lens; integrated privacy shutter.

■ **BUMPS IN THE ROAD** No HDR; plastic; auto focus only; slightly poor microphone.

\$114, www.avermedia.com

SPECIFICATIONS

Video Resolution	1080p @ 60fps
Image Resolution	2.0 megapixels
Still Image Resolution	1920x1080
Video Encoding	MP4
Field of View	95 degrees
Focus Type	Fixed
Connectivity	USB 2.0 A
Microphone	Dual omnidirectional stereo microphones
Weight	0.28lb

techradar.



The home of technology

techradar.com



Pictek PC305

Can a cheap keyboard play with the big boys?

IN THE LAB, we often get the latest and greatest keyboards available to use and review, but what about the other end of the scale? We decided to scour Amazon to find the cheapest mechanical keyboard available on Prime that had over four-star reviews. We ended up with a \$30 Pictek mechanical keyboard, which, unlike many cheaper models, is a legitimate mech-board, rather than a “mechanical feel” keyboard, which you tend to find listed slightly cheaper.

The first thing we noticed was its weight and build quality. The Pictek PC305 is far lighter than most of the keyboards we usually get our hands on, and as expected, it does feel a lot cheaper. There is very little metal involved and the whole board flexes if you try to twist it. When it's on a table, it feels OK, though, and despite the ABS keycaps having a gamer-style font, they don't feel too bad at all. Under the keycaps lie Outemu Blue switches. These are probably the best-known cheap switches on the market. They are similar to other Blue switches, but they are slightly heavier, at 60g. They also have a louder, more obnoxious click and a stem wobble that isn't found in higher quality switches. The switches are not terrible, though; in fact, unless you're used to higher-end switches, and as long as you don't mind the click, they're fine. The PC305 does have lighting, but it's just zoned, with some dynamic effects; it has blocks of color, rather than RGB, but this does give a good result, considering the limitations.

The worst part of the keyboard is definitely the sound it makes. Due to the

cheap materials of the case and the loud Outemu switches, the noise reverberates around the case and creates an echo chamber for the pinging switches. We didn't think it would be possible, but it actually sounds worse than our sample of the Corsair K65 we received recently—much worse, in fact. It is less than one third of the price, though, so it can be forgiven somewhat.

Using the function key, you can control media and volume, and also open Calculator, This PC, Media Player, and a search bar in some programs. There's no software available, so the keyboard's functions are very limited, and there is no way to reprogram it at all. Remember, though, it is only \$30—some boards costing \$100 are in the same boat.

DRINKING GAMES

All in all, the keyboard isn't terrible. That's not to say that it's great, but it's certainly better than we expected. We would say this is a perfect stocking filler or birthday present for younger gamers. YouTube and Twitch influencers are often sponsored by huge gaming brands and usually use \$150–\$300 keyboards. Younger members of the gaming community are likely the ones who are convinced that to be a pro, they need a top-end mechanical keyboard, too. The same youngsters are also the ones who spill a drink, or have sticky fingers, or claim “I went to the kitchen and came back and now the keyboard is just broken and I didn't do anything, honest, Mom.” This is where the Pictek is a great idea. \$30? You could get your kid two and keep

one as a spare. Equally, if you're budget-conscious and don't mind the clickety-clack of Outemu Blues, or the problems caused by the build quality of a budget keyboard, then for the price of a meal, you can have a mechanical keyboard sitting on your desk. It is still leaps and bounds above the majority of membrane boards—in that sense, it's a no-brainer. Having said that, if you're looking to be really impressed by mechanical keyboards, maybe look for something with a heftier price tag. —DAVE ALCOCK

VERDICT
6

Pictek PC305

■ CHEAP AND CHEERFUL

Mechanical switches; checks many boxes for younger gamers; incredible price to performance.

■ **BARGAIN BASEMENT** Horrible resonating switch sounds; very limited lighting and functions; cheap case.

\$30, www.ipictek.com

SPECIFICATIONS

Form Factor	Full-size
Switch Type	Outemu Blue
Switch Durability	N/A
Media Keys	Integrated via Fn key
Connection	Standard 6ft USB 2.0
Battery Life	N/A
Weight	1.93lb
Dimensions	4.72 x 16.93 x 0.98 inches

Shades are common enemies who play a major part in the lore of the game.

**ACTION
RPG**



Nier Replicant
ver.1.22474487139

A relic from yesteryear, or a wondrous remaster waiting for its chance at the limelight?

WE LIKE AN ODDITY, and this is definitely one. An upgraded rerelease of a 2010 Japan-only PS3 game whose sequel, *Nier Automata*, did rather well when released on PC in 2017, *Nier Replicant* (that's the full title above, we'll not use it again) was the final game released by Cavia Games. This prolific Japanese console developer, known for the *Drakengard* titles, was home to *Nier* creator Yoko Taro, a man who always wears a mask in public. For the sequel, Square Enix, which is also behind this remaster, obtained the help of third-person combat specialist Platinum Games to spice things up.

Then there was another game, *Nier Gestalt*, that was also released in 2010,

but this time made it to North America and Xbox 360, where it was just called *Nier*. The two 2010 games featured the same plot, but you played different characters while following it. The success of *Nier Automata* saw Taro become known to a new generation of journalists, and he chose to put out a statement saying the remaster will probably be a commercial failure, because his games always are. Are you keeping up?

Despite its gray pallor and PS3 textures, the original game has become a strange sort of cult classic, with the feeling of a dying developer throwing all it can into the mix in an attempt to make something stick. The result is a

maddening game that this remaster does its best to fix, with varying levels of success. The 2010 games certainly didn't review very well, with complaints about their empty worlds, clumsy combat, and quests we'd all seen before.

But at least the remasters had plenty of source material to work with. A spin-off of the first *Drakengard* game's fifth ending (you all remember that one, yes?) the world of *Nier* has been blighted by illness and monsters, and has become a pastoral, agrarian place that's largely countryside with towns, ruins, and dungeons in between. You play a boy whose sister is ill, so you set out to find a cure. Along the way you encounter a talking book with magical powers (more magical than just being a talking book), a warrior, a boy with Medusa-like petrification abilities who wears a blindfold, and flickering monsters known as Shades, which occupy the areas between towns. There are robots, too, and you'll destroy lots of them with a mix of ranged and melee combat.

The plot continues via kidnapping, cloning, androids, sudden time jumps, interdimensional beings, and another talking book. What initially looks like a fairly standard *Legend of Zelda*-type quest soon becomes darker, questioning

© SQUARE ENIX



Good thing she's in the desert, she'd be cold otherwise.

Emil does not have complete control over his powerful magic.



The scantily clad warrior Kainé is gruff and hides a secret.



You can use one-handed swords, two-handed swords, and spears in battle.

the nature of existence itself. And while you'll play most of the game from the third-person perspective we've seen thousands of times before, the game isn't afraid to flip and switch its perspective and even genre. One section plays out as a text adventure, another an action-RPG like *Diablo*, yet another as a bullet-hell shooter. There are also multiple endings (multiple playthroughs are also encouraged), and accessing some of them requires picking up every single weapon in the game.

NO HAPPY RETURNS

This would be fine, but there's a point of no return in *Nier Replicant*. Once you've completed Part One, there's no going back unless you start a new save file. Miss a weapon (or indeed anything), progress to Part Two, and at least three endings are cut off from you. Getting the weapons requires gold, which is freely available by doing side quests, but the nature of the quests themselves is dull and repetitive, often requiring grinding for resources you can't get through the gardening and fishing minigames.

And this is a bit of a shame, as these side stories are where the game fills in all the little details about its world. Thankfully, there's entertainment at hand

by switching on Auto Battle Mode, in which control of your character during fights is taken from you, and you sit back and watch as he flips and kicks and racks up combos you could never manage with your standard human fingers. Magic is fully integrated into the combat system, which might not hit the highs of Platinum's work on *Automata*, but seems to have learned at least something from the experience, becoming fluid and fast where the original was slow and clumsy.

The graphics are good, but not that good, and they still have the pale lighting look that makes a mockery of modern HDR capabilities. In many ways, this is the game that 2010's *Replicant* should have been, a sort of director's cut made with the aid of new technology. That, however, is with the benefit of 20:20 hindsight, and a wish to see what Cavia might have produced in the past 11 years had it not imploded. At a time when you could pick up the Final Cut version of *Disco Elysium* for all your RPG needs, or all the *Kingdom Hearts* games [the *Final Fantasy/Disney* crossover that forgot about PC until this year] if your needs are more specifically JRPG, then why should you care about this genre-twisting curiosity?

The answer is because in terms of mood and style, there is very little else

like it. Play through this game (and *Nier Automata*, too, although it's a very different setting), and you'll be a member of a rather exclusive club—someone who has seen things others haven't. And while there are still old-fashioned choices in the game—having to manually save at mailboxes, for example—this is a thoroughly modern remaster of a game that didn't really deserve to be forgotten in the way it was.

Whether Taro is right about the game's commercial success or not, stories this rich really deserve to be given a chance to flourish and be experienced by new audiences, and that's just what this remaster provides. —IAN EVENEDEN



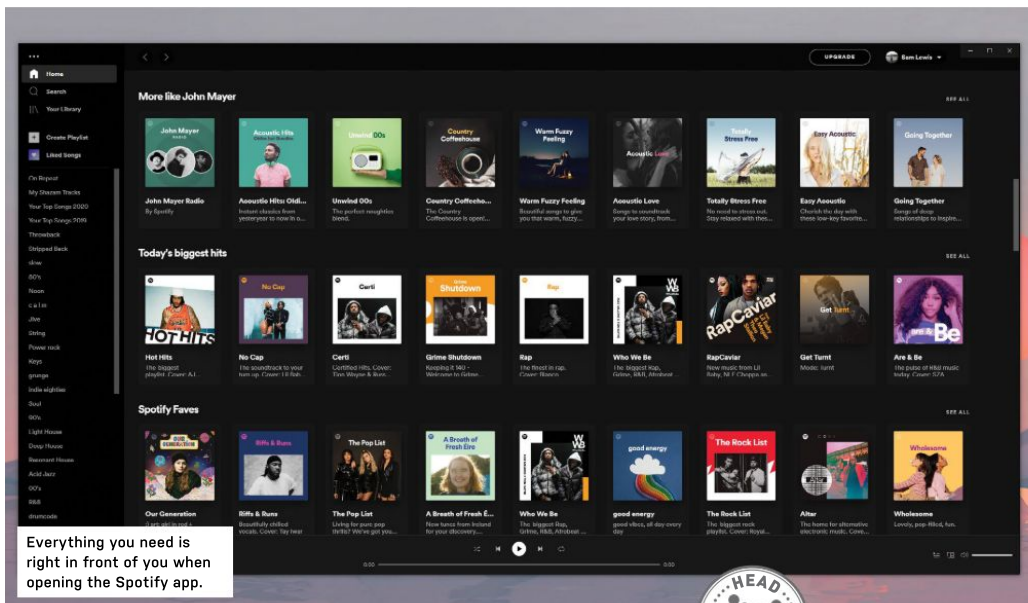
Nier Replicant
ver.1.22474487139

■ **NIER** Interesting RPG that deserves a second chance at attracting a wider audience.

■ **FAR** Could be seen as necromancy taken too far; still manages to have graphical glitches.

■ **RECOMMENDED SPECS** Ryzen 3 1300X or Core i5-6400 CPU; 16GB RAM; Vega 56 or GTX 1660 GPU.

\$60, <http://nier.square-enix-games.com>, ESRB: M



Spotify vs. Tidal

Which music-streaming corner should you back?

BEFORE EACH of the streaming sites starts throwing punches, we need to take a step back to 2011, when the way we consume music began to change. This was when Spotify was widely released and gave the world a new way to experience music consumption. Users could search for and listen to any song that was on Spotify's online library. As a whole, we no longer physically own music; we stream it. Spotify was one of the key founders to push and innovate this new audio age, in which music streaming is a very common household service. For the full packages, you pay a monthly subscription instead of outright physically owning the music—we will dig deeper into this a little later. Since creating this advance in audio listening, Spotify has always been at the forefront of the sector.

Moving on to 2014, and we have a new competitor in the music streaming industry: Tidal. Artist-owned, Tidal aims to deliver the best sound quality within the audio streaming world. Its partnership with MQA (Master Quality Authenticated) enables it to house the biggest catalog of master audio files. Tidal's been making its name with its focus on audio quality and

has been rising in popularity since launch, but where does it stand against Spotify?

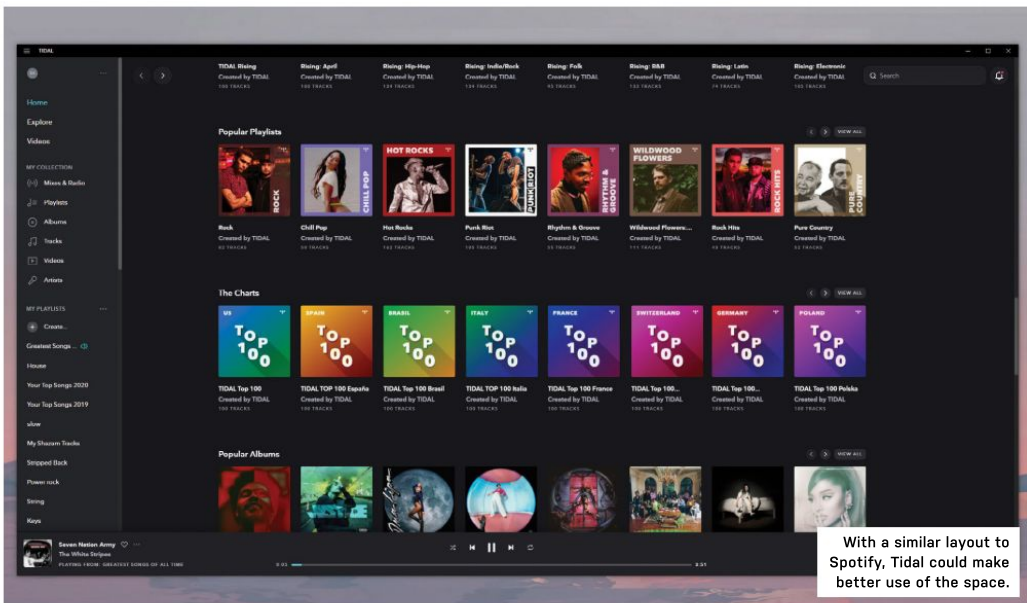
That's the basics covered, but what does Spotify offer the consumer? Well, as well as a library of over 50 million songs, Spotify delivers videos, podcasts, and audiobooks to its audience. Over the years, the software has become incredibly efficient, including features such as Spotify Connect, which enables you to seamlessly switch playback between your devices. Talking of which, the app is super-compatible—you can access Spotify via your PC, Mac, web browser, phone, tablet, speakers, TV, car, games console, smartwatch, and more. That's pretty impressive, to say the least. Seamless integration means that your music isn't interrupted and you can pick up from where you left off. Tidal, on the other hand, takes the short straw regarding compatibility, only being available on PC, Mac, web browsers, and iOS or Android devices. Tidal Connect is a feature that challenges Spotify's seamless nature, but it isn't as fluent as Spotify's pick-up-and-play approach. Where Tidal claims one back over Spotify is its library of music, boasting over 70 million songs—considering Tidal's

later entrance into the music streaming scene, you'd have thought Spotify would take the crown here.

Spotify currently has two subscription models: free and premium. The free offering gives you access to the full library of songs, podcasts, and audiobooks, but the audio quality is lower; there are ads, you can't download your music (though you can download podcasts), on mobile devices you can only pick and play songs on specific playlists, and you can only travel abroad with your music for up to 14 days. Premium costs \$9.99 a month and gives you access to everything with the highest audio quality it offers and the ability to download and listen ad-free. There are also monthly plans for students (\$4.99), families (\$15.99 for six accounts), and a duo account (\$12.99) for two people living together. Spotify shines when it comes to compatibility, with a user-friendly nature that appeals to the masses.

Tidal isn't as versatile and offers two options, one of which is Tidal Premium, a very similar option to Spotify Premium. The other is the most desirable subscription between the two platforms: Tidal HiFi. Both the premium plans from each





platform offer a music bitrate of 320kb/s at \$9.99 a month.

QUALITY ASSURANCE

Where Spotify falls short is audio quality. Spotify HiFi is set to release later this year to challenge this by delivering music in CD-quality, lossless audio format, but this is currently not available—you snooze you lose, Spotify. The HiFi audio that Tidal delivers claims to be “the highest quality audio available” but it costs twice as much as the premium plans, coming in at \$19.99 a month. Is the sound quality worth double the price? Teaming up with MQA, Tidal gives the user the best audio quality available via streaming. On its website, it says it delivers music “as flawless as it sounded in the mastering suite and exactly as the artist intended it to sound.” The bottom line is that with the right gear [a solid pair of headphones or a hi-fi system with an epic pair of speakers], Tidal certainly gives the consumer a much richer experience. Paired with a DAC, Tidal HiFi is the best audio experience you will get via a streaming music site, but that isn't the full package with these platforms.

Regarding the UI experience, Spotify nails this area. Although the overall aim is to deliver music to the consumer at the best quality possible, these streaming platforms have to do it in an efficient and easy-to-use way. For us, Spotify's layout and design just beats Tidal's; it's a little

more vibrant and clear, key factors for a good application. That's not to say Tidal's is bad by any means—in fact, if you switch between the two, you will notice how the layouts are fairly similar, and that's a good thing. Searching on Spotify seems to be more efficient, pulling in what you want. There's nothing worse than remembering a song you love and sifting through the search menus trying to find audio heaven, while trudging through the same old wrong results. Or even worse, giving up because you spelled something slightly differently, resulting in a blank search. This happened very little on both, but more often on Tidal. Luckily, Tidal has an extra trick up its sleeve: It features audio search, a feature that works similarly to Shazam, but built into the app. This is a great time-saving feature, and means you never miss out on finding a song.

Both services provide a very similar experience, but each appeals to slightly different audiences. Tidal's artist-driven platform gives more back to the musicians, supporting the creators who make the world a better place with their music. Its focus on audio quality appeals to audiophiles, and if you fit into this category and have all the gear, Tidal will be more than good enough for you as a streaming device. On the flip side, it isn't as user-friendly and efficient as Spotify. With Spotify offering a variety of plans, it appeals more to the masses, and its Premium plan is by

no means poor quality. With a HiFi release on the horizon for Spotify, it will challenge Tidal when it comes to being the best at audio quality, and this is an area we will be keeping a keen eye on. Overall, Spotify just beats Tidal, thanks to its more versatile approach to delivering music and slightly better functionality. —SAM LEWIS

VERDICT
9

Spotify
AT THE FOREFRONT Extremely versatile platform; seamless playback options; great all-rounder.
LAGGING BEHIND Doesn't offer the best audio quality.
RECOMMENDED SPECS Windows 7 or above, iOS 12 or above, Android OS 4.1 or above, macOS X 10.11 or above.
 \$Free/\$5/\$10/\$13/\$16 p/m, www.spotify.com

VERDICT
8

Tidal
HIGH FIDELITY Best quality music streaming site; gives back more to the artists.
DISTORTED Search function is not as precise; needs a more seamless music connect feature; pricey.
RECOMMENDED SPECS Windows 7 or above, iOS 13 or above, Android OS 6 or above, macOS X 10.10 or above.
 \$10/\$20 p/m, www.tidal.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

- > Newegg Shuffle
- > Dream Machine 2077
- > Subscription Issues

Shuffle Scalping

Hey Zak, Long time reader; great mag and excellent work on your part running it. Thank you for that.

I feel the need to vent here. Yesterday I "won" the chance to buy a GPU from the Newegg Shuffle. After getting the text, I immediately popped over to Newegg to see what I was eligible for. It was the Sapphire Nitro+ AMD 6700XT [\$909], along with an ASRock B550 Steel Legend AMD Micro ATX motherboard [\$155]. My rig is eight years old and really showing its age with its i5 Haswell CPU. The GPU is a 1070 I upgraded to a few years ago.

In my excitement, I immediately purchased the combo for a grand total of \$1,149, then I started wondering whether that price was fair. I did some digging and the stock 6700XT's MSRP should be \$479. I get the times that we are in and I see the Sapphire is an overclocked card, but really, Newegg? \$909 and a \$430 markup!? The RTX 3080's MSRP is \$100 less than that! I don't even want a microATX board. A quick check on eBay shows

the AMD 6700XT sells for around \$900. The card and its motherboard are going right back to Newegg when they get here.

If Newegg is a retail seller and is holding this Shuffle event to "win" a chance to buy these extremely rare cards, it should sell the cards at the MSRP. Not gouge us for hundreds above the MSRP. To me, they are no better than the scalpers.

—Andrew Kilpatrick

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: Hi Andrew. Wow, sounds like you've had the run of it there. Shuffle's weird, in my opinion, and Newegg doesn't always operate like a traditional online retailer either, which doesn't help. It's more akin to a big tech hardware Amazon; a marketplace, rather than a direct store. That's not to say it doesn't have its own products, warehouses, and the like, just that it also allows resellers on there, too, which I guess is what's happened here.

According to Newegg, Shuffle prices should be MSRP, not an inflated price, and to my knowledge, the

Sapphire card MSRP isn't that high. I think some unscrupulous third party has managed to acquire a card, list it in the Shuffle somehow, and adjust the price after the fact, gaming the system. I'm going to reach out to our contacts at Newegg and see what's going on, and I'll let you know what happens.

For those who don't know, Newegg Shuffle is effectively a giant raffle. Each weekday morning, you can sign up to Shuffle using your Newegg account, specifying what type of parts you want. Later in the day, Newegg informs the winners via email if they've won the opportunity to purchase a card, processor, motherboard, you name it. You then get two hours to make your purchase, with a guaranteed product at the end of it (instead of a pre-order list). It's difficult to gauge how many people are in the raffle on any given day, but according to PCmag.com, Newegg informed it that there were around 100,000 people each time. Not everyone's after the same product, and multiple people can be invited to purchase a

selection of products, so it's not a ridiculously low chance to win.

I spent some time speaking to Jarred and Alan Dexter (erstwhile executive editor of *Maximum PC*, currently handling e-commerce at *PC Gamer*) about the chip shortages, and sadly it doesn't seem likely that we're going to see any improvements on the situation until mid-2022 at the earliest.

Dream Machines

Hi Zak, Long-time fan of *Maximum PC* here, from the *Boot days*! What's the situation with Dream Machine? I know hardware is scarce right now, but would love to see the old yearly feature return. Keep up the good work! —Gareth B

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: That's a point of contention right now. I've been thinking long and hard about what to do with regard to the situation. On the one hand, it's a *Maximum PC* staple, a prestigious long-form feature project that we've done one year (most of the time) since the early days, and a project I'm

submit your questions to: comments@maximumpc.com

very fond of. On the other, hardware is so slim on the ground right now that it does feel like a bit of an insult to all the folk who can't get the same kind of hardware we can.

It's part of the reason why I'm slowly stepping away from doing "build" coverlines (a common *Maximum PC* headline), at least for the time being, because it's a bit crap when there's no hardware available to build with, despite us flaunting the latest RTX 3070 or AMD RX 6900 XT. I've been speaking to Tom's Hardware's editor-in-chief, and it seems a lot of other publications are taking a step back from featuring builds for the same reason. That's not to say we're going to stop doing builds in the mag—that is, after all, something I'm very passionate about—but we'll just put less emphasis on them.

What I'm toying with right now is doing a more subdued series of Dream Machines this year to match the current silicon drought. Kris Butterill's working on a fantastic modded build inside an extremely out-there Antec chassis, and I'm thinking of taking the stuff we used in the 4K Gaming PC in the March issue and transplanting it into an epic liquid-cooled soft-tubing (EKWB ZMT black rubber tubing) build you can do yourself at home, with some help from Corsair. Then, maybe just before the chia farming craze kills all the hard drives, we could do a high-end DIY NAS Dream Machine as well. Although that'll likely be a secondary project. We'll see. Hopefully in the next two months you'll see that ZMT build, but until things pick up again with availability, it looks like the big gun show will be away until 2022.

Magazine Delivery

Zak, Has the June issue been sent yet? I usually get

[NOW ONLINE]

PIMORONI KEYBOARD 2040 REVIEW



UK Raspberry Pi reseller Pimoroni has made its own RP2040 "Pi Silicon"-based programmable keyboard, which requires no soldering and comes with 16 keys, all featuring independently controlled RGB LEDs.

Keybow 2040 is Pimoroni's second RP2040-based board, following on from its Tiny 2040, which offered a smaller version of the Raspberry Pi Pico. We took the \$70 Keybow 2040 for a test drive, using it to save us time at the terminal, and to create a colorful light show as we work. Read the full review: <http://bit.ly/PiMoroni>

it by the 6–8th of the month, but nothing yet. After never getting the December issue, I did not want to wait too long on this one. —Ned

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: I've responded to Ned privately via email, and forwarded his concerns to our high-priority customer support team, but wanted to take a little about this here, so everyone can read it.

Magazine distribution, particularly for our subscribers, operates quite weirdly. There's no set date, but you should almost always get it before it goes on sale at newsstands.

Because we create 13 issues a year, our deadlines shift around a fair bit to try to accommodate that extra edition, and to give the team some holiday time over the festive season in December.

With the June issue, we went to press on April 27, and it should go "on sale" on May 25 (long before you read this). After April 27, once all the PDFs are wrapped up (after myself,

Katharine, and Fraser have all signed off the pages), they're sent to the printers, who print and ship them directly to our subscribers.

Depending on where in the country you live, that particular issue can arrive anywhere between May 4 and 28, but almost always turns up two weeks after our print deadline at the latest. There's no hard and fast rule, annoyingly. I've also chased this myself through our distribution team to clarify.

If you're worried you've missed an issue, or that it's got lost in the mail, at the very front of the mag, in my "Editor's Intro," you'll see a little bit of text in the left-hand column that says: "Next Issue On Sale XXX." Take that date, and subtract 10 days. If you haven't received your issue by then, drop me an email at editor@maximumpc.com and I'll forward your complaint to the high-priority team, and we can hopefully get another one sent out to you—free of charge, of course.

Readers' Rigs

Hi *Maximum PC*, Love what you've done with the place, but what about reader rigs? I'd love to see more of the community's PCs in the mag. Maybe you could have a section in "Comments," with some tips or thoughts?

I've got a Fractal Design Meshify C case, still rocking a Core i5-7600K and GTX 1080, and am thinking about upgrading. I've got about \$1,200 saved. What do you recommend I look at first? I want to go AMD but I'm not sure, since I've always been Intel.

—Ed Chester

EDITOR-IN-CHIEF, ZAK STOREY, RESPONDS: That's a good idea—we've done it every now and then, but we don't get a lot of pictures in. So, if you want your rig featured in *Maximum PC*, send a kick-ass photo and some specs/details to editor@maximumpc.com, and we'll endeavor to feature one each issue.

As for your rig, Ed, it sounds like you've got a sweet deal. The GTX 1080 is a fine card, and unless you're looking at changing to a higher resolution, I recommend holding fast for now if you're not having any trouble in games.

If you want to go the AMD route, though, don't worry. We're a long way from the early days of buggy Ryzen BIOSes and desktop software problems. It's a seamless transition; you'll barely know the difference between running an AMD or Intel build outside of some niche tinkering here and there. Heck, it's even easier installing an AMD chip than an Intel one, as you don't really have to worry too much about the socket.

If I were you, and these parts were available at stock prices, I'd try getting something like this: <https://pccpartpicker.com/list/TFWChT>. Transplant them in your current system, then upgrade the case and cooling at a later date. ☺

THE BUILDS

THIS MONTH'S STREET PRICES...

BUDGET



THINGS AREN'T GETTING any easier on the GPU front, are they? Prices from resellers (read: scalpers) have dropped a little since our last issue, but stock is still incredibly hard to find, and the aforementioned scalpers are still buying up as many cards as possible. We're concerned that the arrival of the SSD-leveraging

chia cryptocurrency will cause a similar shortage of drives, but the western market seems largely unaffected so far.

Speaking of drives, we've got some new additions this month. Western Digital's terabyte WD Blue HDDs are once again cheaper than Seagate's competitor, saving us a few bucks on both budget builds this time around. We've also shaved 20 dollars off the price of the Intel machine by swapping the boot drive out for a similar P300 SSD from US manufacturer Patriot. Overall transfer speeds may lag a little behind the Samsung drive it's replacing, but it isn't likely that you'll notice a difference.

We've got new memory for our AMD budget build: 16GB of G.Skill's Aegis RAM at 3,000MT/s. This shouldn't alter performance, but the previous memory was no longer on sale, making the Aegis the budget-conscious option. The AMD Athlon 3000G CPU is still a steal at \$90, but that does make it 10 dollars more than last month, so be sure to keep an eye on price trends if you're looking to buy.

Lastly, we're taking a jump and recommending a power supply from a brand we've not suggested before. ARESGAME looks vaguely suspect at first, and we generally advise against picking up a PSU that seems too cheap to be true, but the ARESGAME AV6500 is typically priced at \$50; a sale currently has that down to \$36, making it an excellent deal. Unlike many shady knock-off PSUs, the AV6500 has solid reviews and an 80+ bronze certification. If you're uncertain about how legit a PSU is, look for user reviews across multiple retailer sites. If it's only available on Amazon, with no mention on Newegg or PCPartPicker, it might be wiser to pass by.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	\$95	
PSU	500W EVGA BA 80+ Bronze	\$35	
Mobo	ASRock B450M-HDV R4.0	\$70	
CPU	AMD Athlon 3000G	\$90	
GPU	AMD Radeon RX 6700 XT 12GB NO STOCK	\$480	\$875
RAM	16GB (2x 8GB) G.Skill Aegis @ 3,000MHz NEW	\$75	
SSD	250GB Samsung 980 Pro M.2 PCIe 4.0	\$90	
HDD	1TB WD Blue 1TB 7200 NEW	\$42	
OS	Windows 10 Home 64-bit OEM	\$32	

Approximate Price: **\$1,009 or \$1,404**

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Corsair 4000D Airflow	\$95	
PSU	500W ARESGAME AV6500 80+ Bronze NEW	\$36	
Mobo	MSI B460M PRO	\$98	
CPU	Intel Core i3-10100	\$115	
GPU	Nvidia GeForce RTX 3060 12GB NO STOCK	\$330	\$930
RAM	16GB (2x 8GB) OLOy WarHawk RGB @ 3,000MHz	\$73	
SSD	260GB Patriot P300 M.2 PCIe 3.0 NEW	\$40	
HDD	1TB WD Blue 1TB 7200 NEW	\$42	
OS	Windows 10 Home 64-bit OEM	\$32	

Approximate Price: **\$861 or \$1,461**



MID-RANGE

LOTS OF CHANGES in our mid-range builds this month. For starters, both machines have swapped over to the WD Blue 1TB hard drive, chasing the price drop of the budget builds. Sorry Seagate; we'll come back when your mainline 7,200rpm drive is cheaper. Our mid-range Intel machine has also got a new SSD, since the Corsair Force

MP600 is no longer on sale. Its replacement is Gigabyte's Aorus Gen4 drive, a great deal at \$95.

Elsewhere, both machines have new power supplies, as we continue to chase the best value for money. The Intel system is now rocking a SuperNOVA PSU from EVGA, while we decided to spring for something funkier in the AMD system: Corsair's RGB-decked CX650-F. RGB lighting on a power supply is something some might turn their noses up at, but Corsair's PSUs are reliable, high-quality products, and the CX650-F is currently on sale for just \$80.

We've made some small tweaks to keep the price totals sensible, with a shift from the ARGB model of Enermax's Liqmax III cooler to the standard RGB, and new RAM for both rigs: Crucial Ballistix for the Intel system, and Team Group's collab with Asus for the T-Force Vulcan TUF special edition sticks. These ensure our system memory performance is top-notch without breaking the bank.

Our AMD rig gets a new motherboard this month, too, the MSI MPG X570 Gaming Plus. We're aware this makes us shills; please direct the relevant hate mail to our inboxes. Still, the X570 Gaming Plus is a solid AM4 board.

Thanks to a small price hike on the Ryzen 3600X, our AMD build didn't come out any more affordable this issue. Our Intel machine, on the other hand, managed to squeeze a few more dollars from the total thanks to its new, more affordable PSU. The RTX 3070 and RX 6800 XT are still near-impossible to find for a reasonable price, so we can't really advise building either machine right now. That said, if you have an RTX 2000 or RX 5000 card, it could fit nicely into both.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-011-Dynamic	\$160	
PSU	650W Corsair CX650-F RGB NEW	\$80	
Mobo	MSI MPG X570 Gaming Plus NEW	\$155	
CPU	AMD Ryzen 5 3600X	\$282	
Cooler	240mm Cooler Master Masterliquid ML240L RGB	\$75	
GPU	Nvidia GeForce RTX 3070 8GB NO STOCK	\$500	\$1,600
RAM	16GB (2x 8GB) Team T-Force Vulcan TUF @ 3,600MHz NEW	\$85	
SSD	500GB Sabrent Rocket 4.0 M.2 PCIe 4.0	\$90	
HDD	1TB WD Blue 1TB 7200 NEW	\$42	
OS	Windows 10 Home 64-bit OEM	\$32	

Approximate Price: \$1,501 or \$2,601

INTEL INGREDIENTS

PART		PRICE	STREET PRICE
Case	Lian Li PC-011-Dynamic	\$160	
PSU	650W EVGA SuperNOVA 650 GA NEW	\$97	
Mobo	MSI Z590-A PRO	\$180	
CPU	Intel Core i7-11700K	\$400	
Cooler	Enermax Liqmax III 240 RGB NEW	\$70	
GPU	AMD Radeon RX 6800 XT 16GB NO STOCK	\$650	\$1,550
RAM	16GB (2x 8GB) Crucial Ballistix @ 3,600MHz NEW	\$93	
SSD	500GB Gigabyte Aorus M.2 PCIe 4.0 NEW	\$95	
HDD	1TB WD Blue 1TB 7200 NEW	\$42	
OS	Windows 10 Home 64-bit OEM	\$32	

Approximate Price: \$1,819 or \$2,719



WE'D LOVE TO TELL YOU that the Intel Core i9-11900K is a sensible purchase right now, but it isn't. Once GPU availability picks up again and the 11th-gen Intel chips drop in price a little, you may want to snap one up. For now, though, we're sticking with the CPUs we've got in these builds, even if the 10900K has risen by \$25. Annoyingly,

our Western Digital HDDs are also a bit more expensive, as it seems that drives with capacities in excess of 4TB are becoming a little hard to find. So are the GPUs.... Well, you know the drill there.

Both of our turbo machines have new power supplies, new motherboards, and new RAM, so let's break it down build by build. The AMD machine has Fractal Design's unobnoxious Ion Gold PSU, a clean, quiet modular power brick from the Swedish manufacturer, plugged into a chunky X570-Plus TUF motherboard from Asus, with 802.11 Wi-Fi and PCIe 4.0 support. Combined with new Viper Steel memory from Patriot, we were able to shave almost 30 dollars off the total price of this system, despite the HDD price hike.

Over on our Intel turbo build, we've got NZXT's modular C750 PSU, which made for a very modest saving with impressively quiet operation. The new motherboard is another MSI offering, the Z590 PRO WiFi, a solid Intel 1200 mobo. Don't look directly at it for too long, though; the monochromatic lines of the design hurt our heads.

The new memory in our Intel system is XPG's Spectrix D41 kit, 2x 16GB at 3,600MT/s. Although XPG isn't the first name that comes to mind when we think of RAM, this kit performs well and looks fantastic, with a soft RGB glow. The Intel build also got a new SSD, the 1TB Rocket Q from Sabrent's top-notch M.2 product line, which costs just \$110; incredibly cheap for a terabyte of PCIe 3.0 storage.

The final addition to these builds is a new cooler for the AMD machine, the Fractal Design Celsius S36. Another 360mm AIO cooler, this bad boy is guaranteed to keep your 5800X running cool. It's not the flashiest of liquid-cooling systems, but it's smartly priced at \$120. If you happen to crave RGB lighting on every part of your PC, you can always feel free to drop another \$30-\$40 on your cooler.

AMD INGREDIENTS

PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	\$140	
PSU	750W Fractal Design Ion Gold 80+ Gold NEW	\$100	
Mobo	Asus X570-Plus TUF Gaming WiFi NEW	\$200	
CPU	AMD Ryzen 7 5800X	\$430	
Cooler	Fractal Design Celsius S36 360mm NEW	\$120	
GPU	Nvidia GeForce RTX 3080 10GB NO STOCK	\$700	\$2,250
RAM	32GB (2x 16GB) Patriot Viper Steel DDR4 @ 3,600MHz NEW	\$160	
SSD	1TB Sabrent Rocket 4 Plus M.2 PCIe 4.0	\$200	
HDD	6TB Western Digital Blue	\$140	
OS	Windows 10 Home 64-bit OEM	\$32	

Approximate Price: \$2,222 or \$3,722

INTEL INGREDIENTS

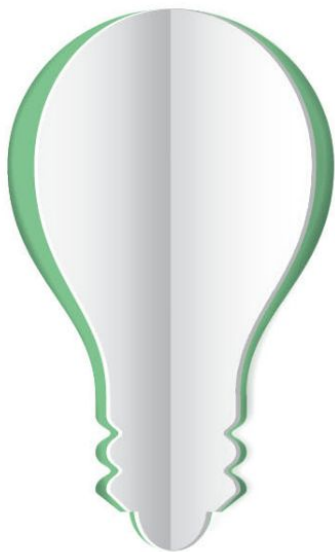
PART		PRICE	STREET PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	\$140	
PSU	750W NZXT C750 80+ Gold NEW	\$120	
Mobo	MSI Z590 PRO WiFi NEW	\$220	
CPU	Intel Core i9-10900K	\$465	
Cooler	Be Quiet! Pure Loop 360mm	\$120	
GPU	AMD Radeon RX 6900 XT 16GB NO STOCK	\$999	\$2,200
RAM	32GB (2x 16GB) XPG Spectrix D41 DDR4 @ 3,600MHz NEW	\$180	
SSD	1TB Sabrent Rocket Q M.2 PCIe 3.0 NEW	\$110	
HDD	6TB Western Digital Blue	\$140	
OS	Windows 10 Home 64-bit OEM	\$32	

Approximate Price: \$2,526 or \$3,727

Maximum PC (ISSN 1522-4279) is published 13 times a year, monthly plus a Holiday issue following the December issue, by Future US, Inc., 11 West 42nd Street, 15th Floor, New York, NY 10036, USA. Website: www.futureus.com. Periodicals postage paid at New York, NY, and at additional mailing offices. Newsstand distribution is handled by Curtis Circulation Company. Basic subscription rates: one year (13 issues) US: \$30;

Canada: US\$30; Foreign: US\$50. Canadian and foreign orders must be prepaid. Canadian price includes postage and GST (GST #R129220688). PMA #40417408. Subscriptions do not include newsstand specials. POSTMASTER: Send changes of address to Maximum PC, PO Box 2024, Langhorne, PA 19047, USA. Future US, Inc. also publishes MacLife, and PC Gamer. Entire contents copyright 2021, Future US, Inc. All rights reserved.

Reproduction in whole or in part is prohibited. Future US, Inc. is not affiliated with the companies or products covered in Maximum PC. Reproduction on the Internet of the articles and pictures in this magazine is illegal without the prior written consent of Maximum PC. Products named in the pages of Maximum PC are trademarks of their respective companies. PRODUCED IN THE UNITED STATES OF AMERICA.



PAPER POWER

67% of the energy demand at U.S. pulp, paper and paper-based packaging mills is met using renewable, carbon-neutral biomass energy.

Discover the story of paper
www.lovepaperma.org

Source: American Forest & Paper Association, 2018





We build the world's most advanced PCs.

Experience a new level of performance with an award-winning Digital Storm PC. Built with the latest technology, highest quality components and backed by lifetime support. Visit our website and build your dream PC today.



LEARN MORE: WWW.DIGITALSTORM.COM

Digital Storm PCs featuring Intel® Core™ i7 processors.

